Assessing Green Business in Asia

A GP excellence framework for green business study across six APO member economies

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ABREVIATIONS

AHP	Analytic Hierarchy Process
AQ	Air Quality
CR	Consistency Ratio
CSR	Corporate Social Responsibility
GB	Green Business
GP	Green Productivity
MCDM	Multi-Criteria Decision Making
RM	Raw Material
RW	Reclaimed Water
ROC	Republic of China
ROK	Republic of Korea
SAW	Simple Additive Weighting
SI	Social Investment
SW	Solid Waste
WP	Water Productivity
WQ	Water Quality

EXECUTIVE SUMMARY

This research report aims to assess the status of green business (GB) in several APO member countries. The study developed an evaluation framework comprising a set of criteria to assess the status of GB among the APO member countries. The framework uses environmental sustainability, productivity and social contribution as the top-level criteria. In order to comprehend and compare diverse aspects, tools like multi-criteria decision making (MCDM), the analytic hierarchy process (AHP), Microsoft Excel and Expert Choice 2000 were used in simulation. A set of two surveys; with Survey 1 covering 367 respondents, and Survey 2 covering 89 companies; was conducted to build and analyze two databases in six countries and to come up with the following results:

i) In the evaluation of GB, respondents in six APO member countries considered environmental sustainability and productivity as the most important first-tier criteria, with scores of 0.550 and 0.246, respectively. The social-contribution criterion, with a score of 0.204, was regarded as relatively less important.

ii) Among all the 14 second-tier criteria, the most highly regarded was air quality with a score of 0.133, followed by water quality (0.111) and the use of renewable energy (0.095). Green label and customer complaints were considered the least important.

iii) All values, by their relative importance, obtained from Survey 1, were added to the corresponding values by actual data, as obtained from Survey 2, in order to rank all the companies. The company CC5, from Republic of China (ROC), was ranked as the best company. The companies EC3 of Indonesia and CC15 of ROC were awarded the second and third ranks [1]. The study also shows the diverse evaluations of 89 companies by country, by scale of productivity, and by GDP per capita.

In conclusion, the study could assess and rank all the participating companies in terms of GB using the Green Productivity (GP) Excellence Framework. With more elaboration of the framework and collection of more accurate data in the survey, the GB Award program could be significantly improved in its applicability.

Through the research, the APO stakeholders can ascertain the potentials, by countries and by industrial sectors; for saving of energy, material and water, and for reduction of greenhouse gases. The outcome of the research can also provide a guideline for Asian companies that are interested in GB. The framework and evaluation methods used in the research can also be used by non-participating companies to compare with the participating companies for greening their businesses.

The research report is structured as follows: First, the introduction provides an overview of the research on the status of GB in the selected APO member countries. Next, section one explains the concept of GP in assessing the GB status. Sections two to four give an outline of the methodology used. Sections five and six explain the framework of evaluation, along with the criteria, and the indicators used in the research. Sections seven and eight show the results of the survey conducted across participating countries. Section nine concludes with a recap.

[1] Company names were coded

INTRODUCTION

BACKGROUND

A GB can generally be defined as a business that strives to reduce its negative impact on the environment by incorporating green practices while maintaining a profit. A GB adopts strategies that demonstrate commitment to a sustainable future. In a scenario where natural resources are becoming scarce and customers are increasingly environmentally conscious, many businesses are integrating environmental dimensions in their business plans and implementing sustainability action plans that will lead to greater value creation, improved productivity, and enhanced corporate image.

In order to monitor and evaluate the effectiveness and performance of a GB, indicators to measure the progress of environmental performance and sustainability of business are important. Against this backdrop, the APO initiated a research to study the extent of adoption of GB practices among the APO member countries. In this research, various indicators or criteria being used to assess GB were reviewed, and a framework with a set of criteria to rate GB practices was established.

A research coordination meeting was convened from 4 to 6 February 2015 in Seoul to discuss the methodology and the overall research framework. The Chief Expert, all national experts and the APO officer in charge of the research attended the coordination meeting and developed the GB Evaluation Framework. All national experts presented their respective country papers as part of the preliminary research activities. The country papers helped to establish a common understanding and to develop an overview of the GB status in different countries. Each paper covered the overview of GB status in the corresponding country; showcasing successful stories or failures of companies adopting GB practices, and successful GB models. This helped in raising the potential challenges in conducting the research and hence in identifying the possible measures that may be taken to overcome the challenges; and determining the critical success factors for an effective research on the status of GB in the APO member countries.

RESEARCH OBJECTIVES

The key objectives of the study were to:

a) Set up a metric framework of criteria and indicators to assess GB
b) Establish the baseline data for the adoption of GB principles and determine the best practices, and
c) Publish a report on the framework for measuring GBs and their best practices in selected APO member countries.

RESEARCH SCOPE AND METHODOLOGY

The starting point of discussion at the meeting was the framework of GP Excellence Awards developed by the APO Center of Excellence (COE) on GP. The GP Excellence Awards

framework was first developed to promote green, sustainable businesses in the APO member countries. The framework, based on the definition of GP, integrates other relevant international frameworks for green enterprises and sustainable awards, making it capable of assessing the environmental performance and productivity of enterprises. The evaluation framework has been structured into four layers: dimensions; aspects; criteria; and indicators. The three dimensions of environmental sustainability; enhancing productivity, sustainable innovation, and social contribution; are included in this framework. Each dimension is broken down into two to three aspects, and each of the aspects comprises one to four criteria. Each criterion has several indicators for performance evaluation.

All experts discussed the practicality and usability of the GP Excellence Awards framework in order to assess the GB status of enterprises. Upon modification and refinement of the GP Excellence Awards framework, a new framework of criteria to evaluate and rank the performance of GB was adopted. This newly modified GP Excellence Framework covers various aspects of environmental sustainability. All national experts agreed on a common methodology for conducting the research as well as a way to address difficulties that may occur during the project. The multi-criteria decision making (MCDM) method and the analytic hierarchy process (AHP) were introduced and agreed upon by all experts.

GP CONCEPT FOR ASSESSING THE GB STATUS

The concept of green development needs to be discussed before moving to GP. According to UNEP, a green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Green development is driven by public and private investments that reduce carbon emissions and pollution; enhance energy and resource efficiency; and prevent the loss of biodiversity and ecosystem services.

As the environmental risks have increased at a global scale, many companies have begun to anchor their business strategies to the green growth initiatives of the governments as a new business opportunity. Earlier, production and consumption without environmental concerns have led to severe global changes; such as climate changes and global warming. Natural resources were inefficiently consumed, which led to many environmental disasters throughout the world. The concept of green development is qualitative and broad, while the concept of green growth is quantitative and narrow.

The APO launched its GP program in 1994, in line with the 1992 Earth Summit recommendations that both economic development and environmental protection would be key strategies for sustainable development. The APO first conceived GP in 1994 as "a strategy for simultaneously enhancing productivity and environmental performance for overall socio-economic development."

Several initiatives to promote GP as a practical way to respond to the challenges of sustainable development have been implemented. The trends of global environmental pollution, green-house gases (GHG), and environmental degradation stemming from a fast economic growth have highlighted the importance of intensifying the promotion of GP in order to address such challenges and to lay the foundation for building greener economies and enforcing GB practices for enterprises in the APO region. A lot of GP knowledge and best practices have been transferred through these initiatives and gained roots in the APO member countries. Applying the GP concept into assessing green business performance is one of those initiatives. This research adopts the GP Excellence Awards framework developed by the APO to assess the GB status of enterprises in the selected APO member countries.

To evaluate the extent of adoption of GP in assessing GB, a high level of expertise and lot of time is required to examine the impact and effectiveness of business implementation. Various legitimate aims, leading to trade-offs have to be weighed against each other. To increase the acceptance and effectiveness of GB, different values of different stakeholders should be considered.

In evaluation of GB, multi-criteria evaluation is an appropriate tool since it allows taking into account a wide range of evaluation criteria; not simply profit maximization but also other considerations [2]. Different value and criteria can be conflicting, multidimensional,

[2] Munda, G., 2003, Multicriteria Assessment. International Society for Ecological Economics, Internet. Encyclopedia of Ecological Economics.

incomparable and incommensurable. As a tool for conflict management, multi-criteria evaluation has demonstrated its usefulness in many green management policies.

The evaluation of green business should be based on the priority orders and weights among the criteria such as environmental sustainability, productivity, and social contribution. The evaluation of GB should be based on achievability of the policy objectives, not only to enhance productivity and protect the environment, but also to improve social benefits and human welfare.

EVALUATION METHOD

Multi-criteria evaluation can help develop and articulate value judgment in a systematic way that can be used to:
i) Rank alternatives
ii) Gain insights on the implication of different judgments and ways of viewing the problem
iii) Identify consensus positions of disagreement within the group, and
iv) identify alternatives that creatively address fundamental concerns [3].

AHP, developed by Satty [4], is a method to find an optimal alternative through hierarchical analysis and pairwise comparison of a wide range of criteria or attributes. AHP is a realistic and clear decision-making method because it includes and measures all important tangible and intangible factors, as well as the quantitatively measurable and qualitative factors. It also allows for differences in opinion and conflicts. Because of its simplicity and clarity in comparing companies for GP, AHP is an appropriate tool for the study. The extraction of evaluation criteria related to GP and the analysis of relative importance among various evaluation criteria can be done with AHP.

[3] Benjamin F.H., Meier P. Energy Decisions and the Environment: A Guide to the Use of Multicriteria Methods. Boston: Kluwer Academic Publishers; 2000.
[4] Saaty T. The Analytic Hierarchy Process. New York: Mcgraw-Hill; 1980.
Saaty T., Kearns K. Analytical Planning, RWS Publication; 1985.

EVALUATION PROCESS

A typical multi-criteria problem having a discrete number of alternative options may be described with *A* being a finite set of *n* feasible options; *m* being the number of points of views for a set of relevant evaluation criteria E, represented by e_i, where i=1, 2, … , m; and the option *a* being evaluated to be better than the option *b* according to the i^{th} point of view if $e_i(a)>e_i(b)$.

In this way, a decision problem may be represented in a tabular or matrix form. Given the sets *A* (of alternative options) and *E* (of evaluation criteria), and assuming the existence of *n* options and *m* criteria, it is possible to build an $n \times m$ matrix *P* called the evaluation matrix, where a typical element p_{ij} (i=1, 2, …, m, j=1, 2, …, n) represents the evaluation of the *jth* option by means of the *ith* criterion. The evaluation matrix can include quantitative, qualitative or both types of information. There are a wide set of multi-criteria methods to find compromise solutions in a multi-criteria problem.

AHP is partly used to derive the relative importance of the criteria for evaluating GB, from the weights assigned to the criteria by respondents in the research. To draw the evaluation criteria for GB, it is needed to conduct a survey of those who are engaged in the GB field.

The survey intends to draw systemically the value judgments of evaluation criteria from the survey participants. The survey process is as illustrated in Figure 1.

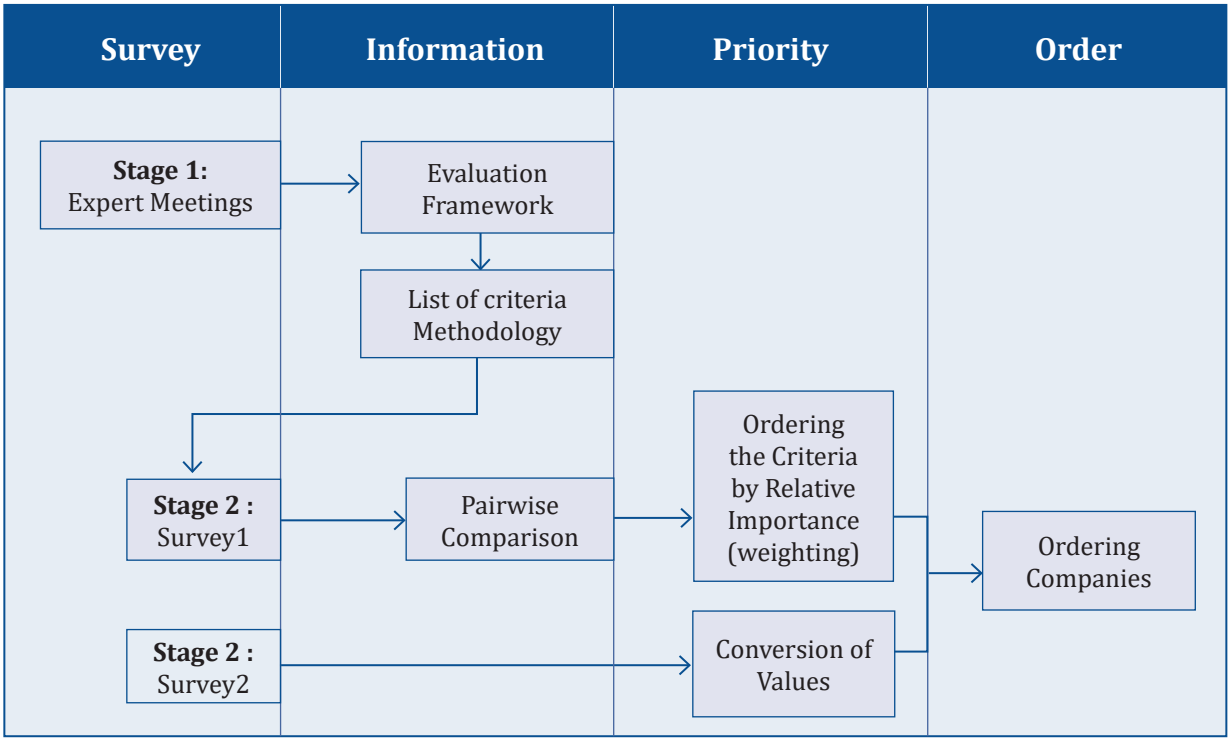

Figure 1. Diagram of the evaluation process

The survey consisted of two stages: Stage l was to build the evaluation framework, evaluation criteria, and assessment indicators for GB. Stage 2 was to assign the relative importance to

the evaluation criteria selected in Stage 1. It is anticipated that the respondents have, and reveal, various interests in GB in their respective survey responses.
In the beginning of AHP, the larger system in the upper hierarchy can be developed to comprehend distinct pieces of information and interest. The larger system is broken up into subsystems, almost like the schematic of a computer, which consists of blocks and their interconnections, with each block having a schematic of its own.

In the research, the steps of AHP for optimal decision making are as follows:

a) Define problems, planning goals and generating alternatives through literature review, data survey, and brain storming by the APO national experts
b) Identify and extract the hierarchical evaluation criteria
c) Implement pairwise comparisons of each evaluation criteria on a seven-point scale. Relative importance of evaluation criteria can be expressed in the matrix:

$$A = (a_{ij}) = \begin{bmatrix} 1 & a_{12} \dots a_{1n} \\ a_{21} & 1 \dots a_{2n} \\ \vdots & \\ a_{n1} & a_{n2} \dots 1 \end{bmatrix} \qquad (1)$$

where a_ij is the value of i representing the relative importance of the option j in the criteria, and

$$a_{ji} = \frac{1}{a_{ij}}$$

Through the survey, opinions of respondents on the value of pairwise comparison matrix can be obtained.

d) Analyze the survey data, and calculate the relative importance and consistency ratio for each alternative. If consistency is not secured, simulate again the third stage of analysis until consistency is secured.
e) Finally, drive priorities among alternatives by composing the weights in the hierarchy [5].

[5] Kim J., et al. Extraction of Evaluation Criteria on Technology and Service Related to Smart Grid; and Analysis of Relative Importance among Evaluation Criteria by AHP Method. Journal of Environmental Policy and Administration 2013; Vol. 21. No. 3: 130-131(Korean).

CHECKING THE CONSISTENCY

When many pairwise comparisons are performed, some inconsistencies may typically arise. The AHP incorporates an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process.

Consistency ratio (CR) in AHP is an important index representing the consistency in judging and measuring the survey data. The deviation from consistency can be represented by $(\lambda_{max} - n)/(n - 1)$, which is the consistency index (CI).

$CI = (\lambda_{max} - n)/(n - 1)$ (2)

λ_{max} : the maximum or principal eigenvalue

n: the number of activities in the matrix

$CR = CI/RI \times 100\%$ (3)

In order to have a CR, the random index (RI) is required. RI is presented in Table 1.

Table 1. Random index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty, T. 1980: 20

The ratio of CI for the same order matrix is called the CR. A consistency ratio of 0.1 or less is considered acceptable [6]. In particular, CR of 0.2 can be allowed in case of difficulty in securing indifference among evaluation criteria or unfamiliarity of respondents in the AHP survey [7] [8].

[6] Saaty T. The Analytic Hierarchy Process. New York: Mcgraw-Hill: 1980, 20.

[7] Park, C.K., et al. Analysis of Selection Index Priorities of Settlement Environmental Improvement Projects by AHP, Journal of Korea Energy Engineering 2000; Vol. 9. No. 3: 269-277 (Korean).

[8] Ko J.K. A Study on Priorities to Enhance Local Environmental Governance Capacity. Journal of Environmental Policy and Administration 2009; Vol. 17. No 2: 73–114 (Korean).

EVALUATION CRITERIA AND FRAMEWORK

EVALUATION CRITERIA

In order to assess GB, a wide range of criteria or attributes should be taken into account, rather than simply focusing on the productivity or cost minimization. Trade-offs among fundamental concerns should be treated more explicitly. Among conflicting values, there is no one solution optimizing all the criteria at the same time. Before evaluating companies and reaching a social ranking of the companies, it is needed to detect what is regarded important by different social actors at the APO. That is, drawing the evaluation criteria for the policy out of social actors must be done ahead of deciding if a choice of excellence is socially desirable and could be introduced into the APO member countries.

There is an irreducible value conflict when deciding what common comparative terms should be used to rank alternative actions [9]. In a society, there are different legitimate values and points of views. This creates social pressure for taking into account various dimensions such as the economic, environmental and social. To weigh different criteria implies giving weights to different groups in the society.

GB involves multiple actors such as governments, corporates, researchers, and citizens. None of these actors can be expected to make decisions based on single averaged values. Their decisions have been influenced by conflicting values and perspectives. While corporates have focused on productivities and encouraged the technological innovation and/or cost minimization, societal perspectives require more than economic efficiency and environment and social welfares.

EVALUATION FRAMEWORK

In stage 1, one group of experts assigned by the APO, developed the concept and framework of GP Excellence in Asia and two tiers of specific evaluation criteria through both the framework meetings in ROC. In the later stage, another group of experts met in Seoul to review the framework and its applicability. Environmental sustainability, productivity and social contribution are the main criteria of the framework developed at stage 2. The evaluation criteria and prioritizing alternatives are illustrated in Figure 2.

[9] O'Connor M., et al. Emergent Complexity and Procedural Rationality: Post-Normal Science for Sustainability. Robert C., Olman S., Juan M. (eds.). Getting Down to Earth: Practical Application of Ecological Economics, Island Press: 1996, 223-248.

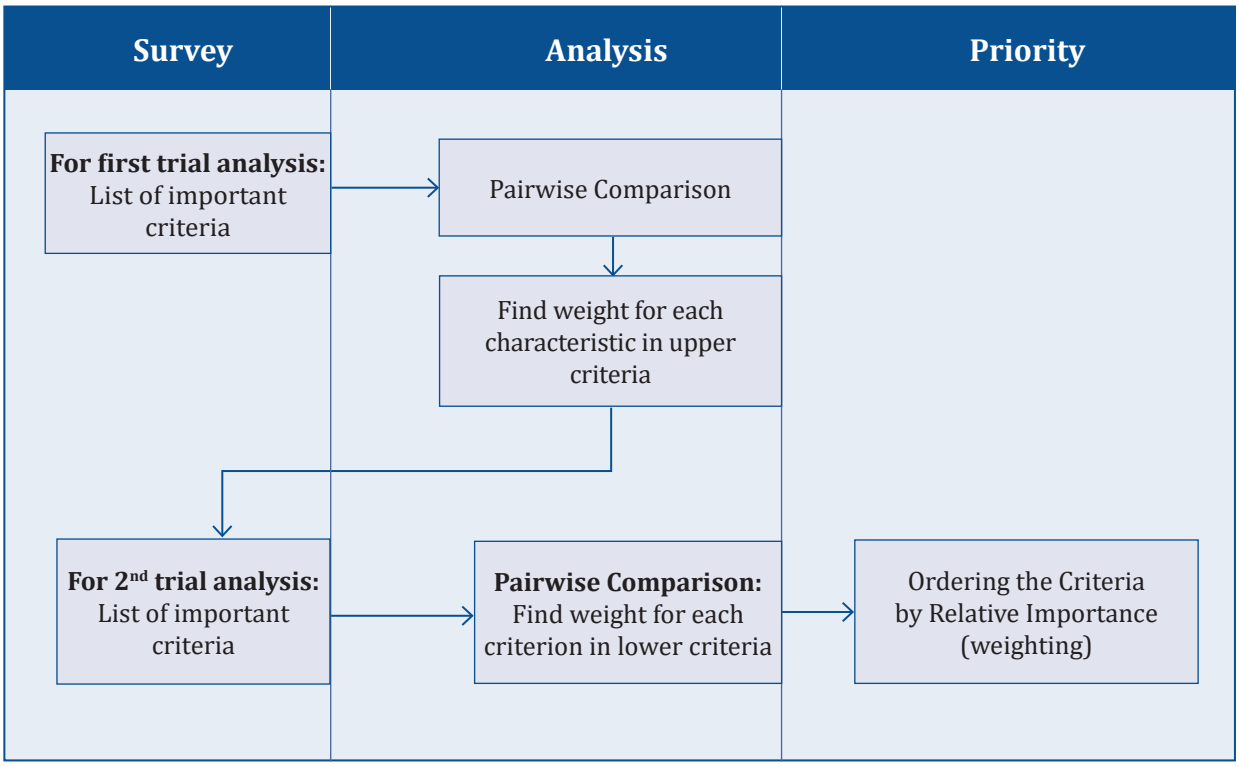

Figure 2. Diagram for evaluation criteria and prioritizing alternatives

Environmental Sustainability

The main purpose of this dimension is to evaluate the extent to which the applicants reduce their environmental impacts yearly. This dimension has two aspects: dematerialization and detoxification. For the dematerialization aspect, raw material consumption, renewable energy and reclaimed water are important criteria in the concept. For the detoxification aspect, the discharge of toxic and hazardous materials or wastes must meet regulatory requirements of the country and should decrease yearly. Air and water quality, solid waste, and hazardous waste materials are categorized in the second evaluation criteria. In the study, the decarbonization aspect, or the reduction of greenhouse gas (GHG) emissions, is assumed to be included in the criteria of dematerialization. This is because, energy and resource usage, which are main causes of GHG, are included in the dematerialization. Finally, these two criteria are applied to all industry sectors in the context of environmental sustainability.

Productivity

The framework includes several aspects of general productivity, i.e. labor productivity, material productivity, energy productivity, and water productivity. Energy and water productivity aspects are included to analyze how added value is created by workers, by energy, and by water consumed by the organization. The idea behind these criteria is that profitability is the bottom line of a corporation, which thus needs to have high productivity to gain green competitiveness. Hence, all indicators are translated into financial (monetary) units to represent a win-win of economic, energy, and water efficiencies.

Social Contribution

Challenges to sustainable development are believed to be so huge that the goal cannot be achieved using only conventional approaches. Rather, we need to adopt innovative, creative solutions to solve the most difficult global issues. In light of this, corporate social responsibility (CSR) is integrated into the framework. Social investment of enterprises is to be manifested not only in general novel ideas but also in making contributions to the communities and driving sustainable development as a whole. Sustainable or competitive enterprises also need to be socially and ethically responsible, and should focus on how to make significant social contributions. Most importantly, social issues vary for different countries and are sometimes locality- and community-specific. Moreover, a dimension may have specific evaluation criteria by which an investment or contribution by the applicants is assessed. For example, the dimension of safety with regard to health, requires the enterprises to provide the number of industrial incidence inside and outside. Similarly, the criteria of green label or certification and customer are related to the current number of labels or certification and any channel for customer complaints, respectively. This aspect of the award encourages social contributions.

GP is not only to enhance productivity and protect the environment but also to promote social benefits and human welfare. Based on the APO's definition of GP and in light of the actual and uneven economic situations of the APO member countries, the proposed evaluation framework is structured into three layers of criteria and indicators. The three dimensions of environmental sustainability, productivity, and social contribution are included in this framework. These constitute the first trial of the evaluation criteria. The dimension of environmental sustainability in the first trial is broken down into two aspects, while the other two dimensions remain the same. Each of these aspects comprise three to four items in the next level of criteria. Each criterion has several indicators for performance evaluation (Figure 3).

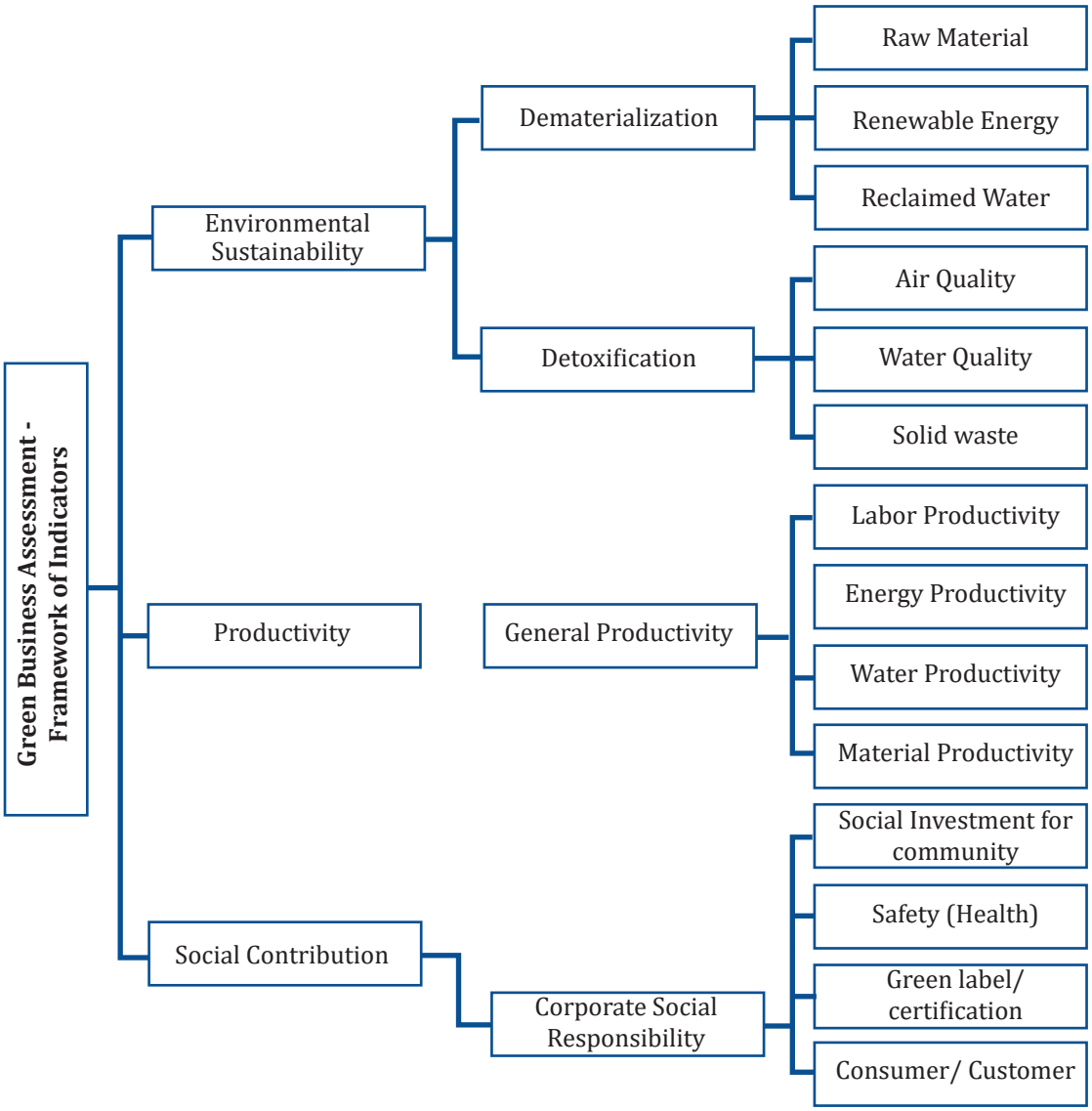

Figure 3. GP Excellence Framework

EVALUATION INDICATORS

Environmental Sustainability 1 (Dematerialization)

Companies should demonstrate their environmental performance by continuously reducing the intensity of their consumption of raw materials, non-renewable energy, and water resources. Use of recycled material, renewable energy and reclaimed water can reduce this intensity. In the study, companies were asked to provide data for the most recent year on the dematerialization aspect, based on which the following indicators were calculated:

Raw material: Consumption of recycled material as a percentage of total material consumption

Renewable energy: Consumption of renewable energy as a percentage of total energy consumption, and

Reclaimed water: Consumption of reclaimed water as a percentage of total natural water used. (See Annex 2 for details of data provided by companies)

Environmental Sustainability 2 (Detoxification)

Companies should control and treat all toxics produced by their operations. In the long run, companies are expected to treat and manage all discharge of air, water, and solid waste generated by their operations, with emphasis on showing the reduction in discharging toxins into air, water, and earth. In the survey, companies were supposed to provide the following specific data for the most recent year pertaining to detoxification.

1) **Air quality:** Emissions of air pollutants, including SOx, NOx, VOC and other toxics
2) **Water quality:** Total volume of water discharged by destination (BOD, COD and other toxics)
3) **Solid waste:** Total amount of solid waste and hazardous waste materials.

(See Annex 2 for details on data provided by the companies.)

Productivity

Companies were requested to disclose revenue growth for the most recent year, and any new capabilities or factors that demonstrated a sustainable growth of the company. Companies are expected to demonstrate continuous improvement in labor, energy, water and material productivity. In this survey, we asked for just one year's performance, because it was difficult to have the time-series data. Each productivity element is defined as an economic value created every year per person per unit of energy, water and material consumed. The unit for measuring the value added is USD, and is defined as below for various categories:

1) **Labor productivity:** Economic value created every year per person in the labor force (value added/employee)
2) **Energy productivity:** Economic value created every year per unit of energy consumed (value added/kcal equivalent)
3) **Water productivity:** Economic value created every year per unit of water consumed (value added/m3 of water)
4) **Material productivity:** Economic value created every year per unit of material consumed (value added/ton of raw material).

(See Annex 2 for details of data provided by the companies.)

Social Contribution

Companies should provide a description or explanation of their efforts toward social contribution and sustainable development. The parameters listed below should be the key basis for judging the impact:

Social investment: Amount of investment toward social contribution
Safety (health): Number of industrial incidents inside and outside the plants
Green label and certification: Current number of such labels and certifications
Customer complaints: Any channel for the customer complaints.
(See Annex 2 for details of data provided by the companies)

Under social contribution, data for each criterion was not appropriately obtained, so the data for simulation was inputted as either the number 1 or 0. If a company has done an investment toward social contributions, 1 was inputted. If not, 0 was inputted.

PAIRWISE COMPARISONS AND COMPANY SURVEY

PAIRWISE COMPARISON

Based on the hierarchical evaluation criteria and framework, the Chief Expert and national experts developed two types of survey questionnaires. Survey 1 was for diverse types of respondents, to check the relative importance of first- and second-tier criteria by comparing the two with each other. In the survey, respondents were classified into four groups by types of their organizations, i.e., education and research, company, government, and others. Given the high level of their awareness in GB, it can be stated that the validity and reliability of the survey is high.

Survey 2 was designed for companies, to fill out actual data for their performance against the various evaluation criteria. Their replies on questions are integrated with weighted values gained from Survey 1. The final evaluation of performance and ranking of the companies within this framework is determined by these two surveys.

Our survey for the research was conducted across six countries between March 2015 and October 2015. The numbers of respondents by countries are provided in Table 2. Total number of respondents is 367 for Survey 1 and 89 for Survey 2.

Table 2. Number of respondents

Country	Survey1	Survey2
ROC	226	15
India	50	30
Indonesia	35	8
ROK	14	7
Philippines	17	13
Thailand	25	16
Total	367	89

In the analysis of AHP, the consistency of answers in the survey is more important than the size of samples. However, the sample size in our analysis is large enough for securing the validity of the research. The only thing we need to consider in the real awarding program is to moderate the size of Survey 1 in the case of ROC with the size of other countries. This is because the ROC's opinion can significantly influence the weighting values of the criteria.

Table 3 in the next section shows the example of survey questions in evaluating the relative importance of first-tier evaluation criteria, while Table 4 shows the example of survey questions in evaluating the relative importance of second-tier evaluation criteria in the case of productivity (See Annex 1). Since both the survey questions are similar, the survey experience in the first tier could make the respondents easily follow the survey in the second tier.

This is to implement pairwise comparisons of each evaluation criteria with a seven-point scale. The relative importance of an evaluation criteria can be expressed in the matrix. Through Survey 1, opinions of respondents on the value of pairwise comparison matrix can be obtained.

Relative importance of the evaluation criteria for GP can be calculated from the pairwise comparison matrix which is obtained from the second survey. The weights of attributes can be derived by using eigenvector of the pairwise comparison matrices.

The pairwise comparison matrix A can be represented as follows:

$$\begin{bmatrix} a_1 & a_1 & \cdots & a_{1n} \\ a_1 & a_2 & \cdots & a_{2n} \\ a_1 & a_2 & \cdots & a_{3n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_n \end{bmatrix} = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ w_3/w_1 & w_3/w_2 & \cdots & w_3/w_n \\ \vdots & \vdots & & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix}$$

where $\sum_{j=1}^{n} w_j = 1$ (w_j : relative importance of the evaluation criteria j)

The matrix A is a reciprocal matrix which has the following property:

$$a_{ji} = 1/a_j \,,\; a_{ji} = a_k \cdot a_{jk}$$

In general, since the pairwise comparison values a_{ij} are assigned subjectively by the respondents, they are inconsistent. The infinitesimal variation of matrix elements causes a small change of the eigenvalue. If *A'* represents the pairwise comparison matrix of the respondents, the relative importance vector W of the evaluation criteria can be obtained as following:

$$A'W = \lambda_{\max} W$$

Where $\lambda_{\max}$ is the largest among the eigenvalues. The corresponding eigenvector become the relative importance vector W.

SURVEY QUESTIONS

Respondents were asked to rate the relative importance of criteria by comparing each criterion with others. Table 3 and Table 4 below show the examples of questions for first-tier evaluation criteria. For example, if one considers that environmental sustainability (criteria A) is strongly more important than productivity (criteria B), one gives the value 5 or 4 in the table (left hand side). If one considers productivity (criteria B) is slightly more important than environmental sustainability, one gives a value of 2 or 3 in the table (right hand side).

Table 3. Survey questions for first-tier evaluation criteria

A	A is more important than B						Equal	B is more important than A						B
	Very strongly, strongly, slightly							Slightly, strongly, very strongly						
Environmental sustainability	7	6	5	4	3	2	1	2	3	4	5	6	7	Productivity
Environmental sustainability	7	6	5	4	3	2	1	2	3	4	5	6	7	Social contribution
Productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Social contribution

Table 4. Survey questions for second-tier evaluation criteria (productivity)

A	A is more important than B						Equal	B is more important than A						B
	Very strongly, strongly, slightly							Slightly, strongly, very strongly						
Labor productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Energy productivity
Labor productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Water productivity
Labor productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Material productivity
Energy productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Water productivity
Energy productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Material productivity
Water productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Material productivity

Table 5 below is a sample of survey questionnaire for companies to collect actual data for their performances in GP (see Annex 2). Respondents were asked to rate the relative importance of various criteria by comparing each criterion with others in Survey 1. The relative importance of evaluation criteria obtained from Survey 1 is calculated with the values obtained from Survey 2. The simple additive weighting (SAW) method is used in the analysis. If consistency is not secured, the previous stage of analysis is simulated again until consistency is secured. Finally, the study drives priorities among companies by composing the weights in the hierarchy [10].

[10] Kim J., et al. Extraction of Evaluation Criteria on Technology and Service Related to Smart Grid and Analysis of Relative Importance among Evaluation Criteria by AHP Method. Journal of Environmental Policy and Administration 2013; Vol. 21. No. 3: 130-131 (Korean).

Table 5. Survey questions for companies (productivity)

Criteria	Formula	Data
Labor productivity	Production (value added/total employees (y)	
Energy productivity	Production (value added/energy consumption (y)	
Water productivity	Production (value added/water consumption (y)	
Material productivity	Production (value added/material consumption (y)	

SIMPLE ADDITIVE WEIGHTING (SAW)

SAW is a commonly known and very widely used method for providing a comparative evaluation procedure in MCDM. SAW uses all criterion values of an alternative and employs the regular arithmetical operations of multiplication and addition [11]. Also known as weighted linear combination or scoring methods, SAW is a simple and often used multi-attribute decision technique.

The method is based on the weighted-average technique. An evaluation score is calculated for each alternative by multiplying the scaled value of the alternative with the weights of relative importance directly assigned by the decision maker, followed by a summation of the products for all criteria. The advantage of this method is that it is a proportional linear transformation of the raw data, which means that the relative order of magnitude of the standardized scores remains equal.

The steps for SAW [12] are:

1) Obtain the normalized decision matrix from the decision matrix using equation 4 given below if the jth criterion is a benefit criterion, and equation 5 if it is a cost criterion

$$\mu_{ji} = \frac{x_{ij}}{max_i x_{ij}} \qquad \text{..... (4)}$$

$$\mu_{ji} = \frac{\frac{1}{x_{ij}}}{max_i \frac{1}{x_{ij}}} = \frac{min_i x_{ij}}{x_{ij}} \qquad \text{..... (4)}$$

2) Obtain the weighted decision matrix by multiplying each column of normalized decision matrix by the corresponding weight
3) Obtain the score for each company by summing the weighted values for each company, and rank the companies according to this sum.

[11] Chen T.Y. Comparative Analysis of SAW and TOPSIS based on Interval-valued Fuzzy Sets: Discussions on Score Functions and Weight Constraints. Expert Systems with Applications; 2012, 39, 1848–1861.

[12] Kim J. Evaluation of Priority in Environmental Contribution by Multi-criteria Decision Making. Environmental and Resource Economics Review 2004; Vol. 13. No. 2: 250-251 (Korean).

OUTCOME OF ANALYSIS 1

CHECKING CREDIBILITY OF SURVEY

Before simulating the relative importance, CR was obtained from equations (2) and (3). The overall CR for the first-tier criteria was 0.028, while at the country level, it was 0.275 (India), 0.005 (Indonesia), 0.002 (Philippines), 0.01 (ROC), 0.012 (ROK), and 0.083 (Thailand). In the case of India, the CR value of 0.275 shows a little lower level of reliability. If there was an award program for Indian companies only within the country, the responses to Survey 1 (India) need to be checked and answer sheets that significantly lack consistency be removed. Within the scope of this research, the Indian sample size was not big enough to drive the CR of all participating countries to an unreliable level, i.e. 0.2. Thus, the credibility of CR in this research is secured.

CR scores in the second tier were 0.016 (dematerialization), 0.01 (detoxification), 0.046 (productivity), and 0.10 (social contribution).

The research used Microsoft Office Excel 2010 and Expert Choice 2000 in the simulation of the analysis, derived the weighted value for the criteria, and finally obtained the priorities among companies by composing the weights in the hierarchy [13], with the values of each company through each criteria.

RESULTS OF SURVEY 1

Table 6 shows the weighted value and order by the first-tier and second-tier criteria derived from the 367 respondents across the six selected APO countries. As shown in Table 6, the order of relative importance for the three first-tier criteria in six Asian countries was environmental sustainability (0.550), followed by productivity (0.246), and social contribution (0.204). Respondents consider environmental sustainability as the most important element in the evaluation of GB, while social contribution was regarded as not very important. This is displayed in Figure 4.

The result showed that Asian people do not give high priority to social contribution in GB. Within the environmental sustainability aspects, detoxification (0.554) has a priority over dematerialization (0.446).

[13] Kim J., et al. Extraction of Evaluation Criteria on Technology and Service Related to Smart Grid and Analysis of Relative Importance among Evaluation Criteria by AHP Method. Journal of Environmental Policy and Administration 2013; Vol. 21. No. 3: 130-131 (Korean).

Table 6. Relative importance and order by criteria

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.550 (1)	0.446 (2)	Raw material	0.330 (2)	0.081 (4)
				Renewable energy	0.386 (1)	0.095 (3)
				Reclaimed water	0.284 (3)	0.070 (7)
	Detoxification		0.554 (1)	Air quality	0.437 (1)	0.133 (1)
				Water quality	0.363 (2)	0.111 (2)
				Solid waste	0.201 (3)	0.061 (9)
Productivity		0.246 (2)		Labor productivity	0.267 (2)	0.066 (8)
				Energy productivity	0.314 (1)	0.077 (6)
				Water productivity	0.222 (3)	0.055 (10)
				Material productivity	0.197 (4)	0.048 (11)
Social contribution		0.204 (3)		Social investment	0.220 (2)	0.045 (12)
				Safety (health)	0.396 (1)	0.081 (5)
				Green label / certification	0.182 (4)	0.037 (14)
				Customer / consumer	0.202 (3)	0.041 (13)

The sum of each weight (relative importance of the evaluation criteria) equals 1. Some are not exactly 1 because of the rounding process.
Final weight comes from multiplication of first-tier weights by second-tier weights.
In addition, weights of dematerialization and detoxification are multiplied with weights of environmental sustainability.

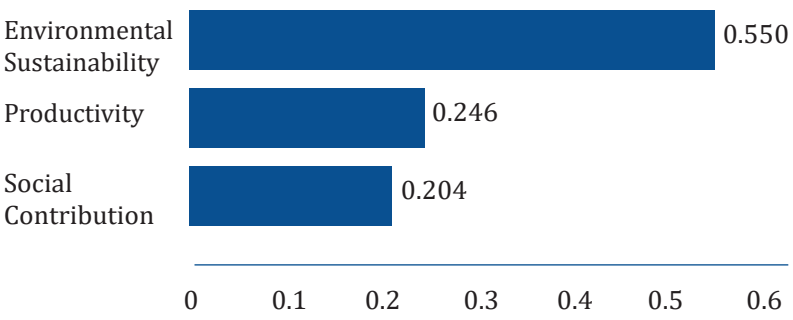

Figure 4. Relative importance of first-tier criteria

In order to know the difference in relative importance among countries, the sum of relative importance should be divided by country. As shown in Figure 5, the order of relative importance in six countries is exactly the same as the order of each country's relative importance. The topmost priority is environmental sustainability, followed by productivity, and social contribution. However, the difference between the values varies from country to country and also from criteria to criteria. ROC's weighted value for the environmental sustainability criterion is very high (0.607), while India's and Philippine's weighted values for the same criteria are relatively low at 0.441 and 0.440, respectively.

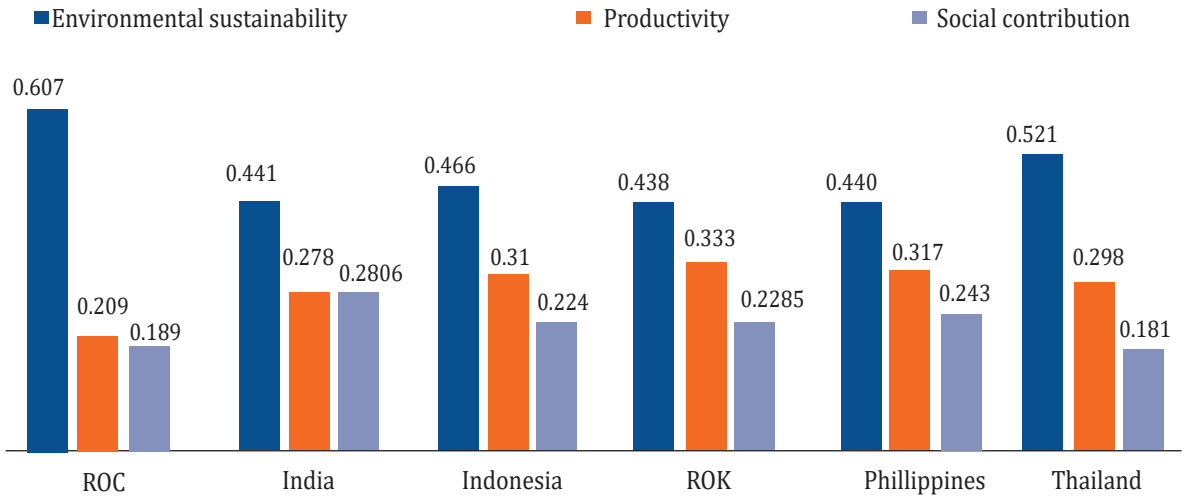

Figure 5. Relative importance of first-tier criteria by country

Among the second-tier criteria corresponding to the dematerialization sub-criterion under environmental sustainability, the priorities were found to be renewable energy (0.386), raw material (0.330), and reclaimed water (0.284), in that very order. Clearly, the respondents considered the use of renewable energy to be relatively more important than the consumption of recycled material and reclaimed water. Similarly, between recycled material and reclaimed water, respondents considered the use of recycled material to be more important than that of water consumption.

Within the environmental sustainability criterion, the detoxification sub-category (0.554) was found to have a higher priority over dematerialization (0.446). Under detoxification, the second-tier category of air quality (0.437) clearly had a higher priority order over other peer categories, followed by water quality (0.363), and solid waste (0.201). Obviously, respondents consider that maintenance of air quality is the most important criterion for attaining environmental sustainability in the production process.

In the second-tier category under the third first-tier criteria of productivity, the highest relative importance was shown with priority order for energy productivity (0.314), followed by labor productivity (0.267), water productivity (0.222), and material productivity (0.197), respectively. This shows that the efficiencies of energy and labor input in production are viewed as more important than other elements in the consideration of GB.

For the forth criteria of social contribution, the highest second-tier relative importance was

shown with priority order for health safety (0.396), followed by social investment (0.220), customer (0.202), and green label and certification (0.182), respectively. Respondents consider that industrial incidence and investment for society are more important than a labeling and certification policy or customer complaints, when it comes to pursuing GB goals.

The final weighting values and orders by criteria is shown in the last column of Table 6. The values are obtained by multiplying weights in the first tier with weights in the second tier in the hierarchy. The most highly regarded elements in all criteria are air quality (0.133), water quality (0.111) and the use of renewable energy (0.095). The consumption of recycled material (0.081) and safety (health) (0.081) are considered as the next important elements in GP. Green labeling (0.037) and customer complaints (0.041) are considered as least important. The final weights and orders are presented in Figure 6.

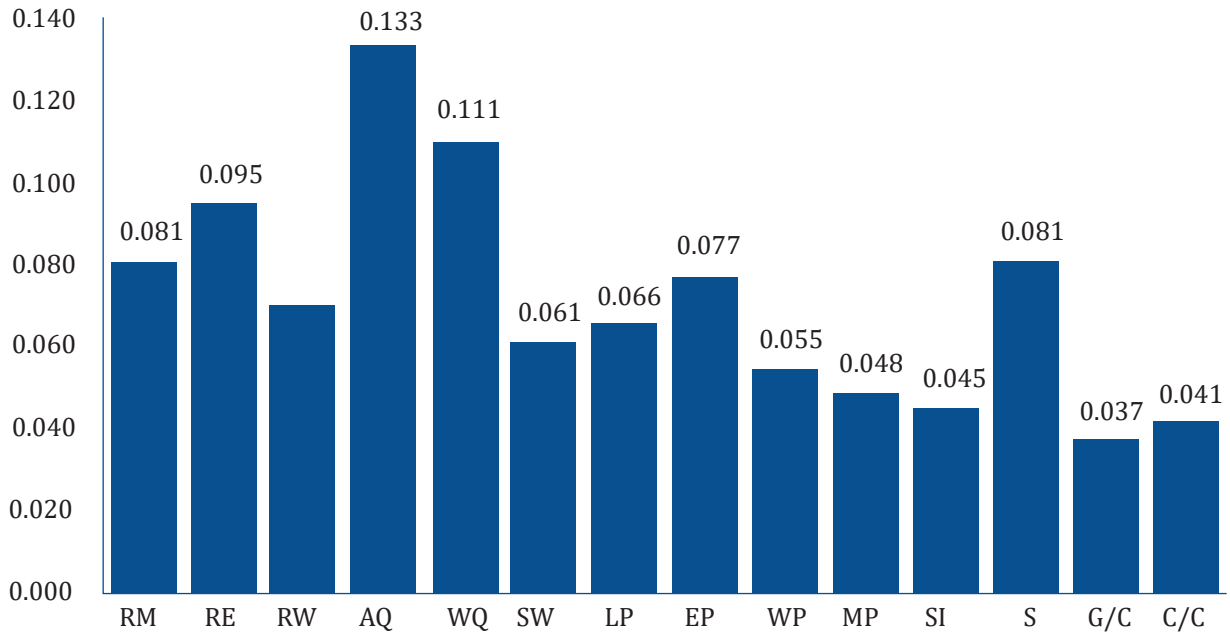

Figure 6. Relative importance of all criteria

RM: raw material, RE: renewable energy, RW: reclaimed water, AQ: air quality, WQ: water quality, SW: solid waste, LP: labor productivity, EP: energy productivity, WP: water productivity, MP: material productivity, SI: social investment, S: safety, G/C: green label/certification, C/C: customer/consumer

For the purpose of a detailed analysis, the six countries in the survey are divided into two groups by GDP per capita [14]. The outcome of an analysis of group 1, in which India, Indonesia and the Philippines are included is shown in Table 7 and Figure 7 below.

[14] The first group of countries have GDPs below USD5,000 while the second group of countries have GDPs above USD5,000 per capita. http://knoema.com/sijweyg/gdp-per-capita-ranking-2015-data-and-charts

Table 7. Relative importance and order by criteria for group 1 (India, Indonesia, and Philippines)

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.442 (1)	0.572 (1)	Raw material	0.361 (1)	0.091 (1)
				Renewable energy	0.357 (2)	0.090 (2)
				Reclaimed water	0.281 (3)	0.071 (7)
	Detoxification		0.428 (2)	Air quality	0.417 (1)	0.079 (6)
				Water quality	0.352 (2)	0.067 (10)
				Solid waste	0.231 (3)	0.044 (14)
Productivity		0.302 (2)		Labor productivity	0.263 (2)	0.079 (5)
				Energy productivity	0.299 (1)	0.090 (3)
				Water productivity	0.212 (4)	0.064 (11)
				Material productivity	0.226 (3)	0.068 (9)
Social contribution		0.256 (3)		Social investment	0.271 (2)	0.069 (8)
				Safety (health)	0.311 (1)	0.080 (4)
				Green label / certification	0.184 (4)	0.047 (13)
				Customer / consumer	0.235 (3)	0.060 (12)

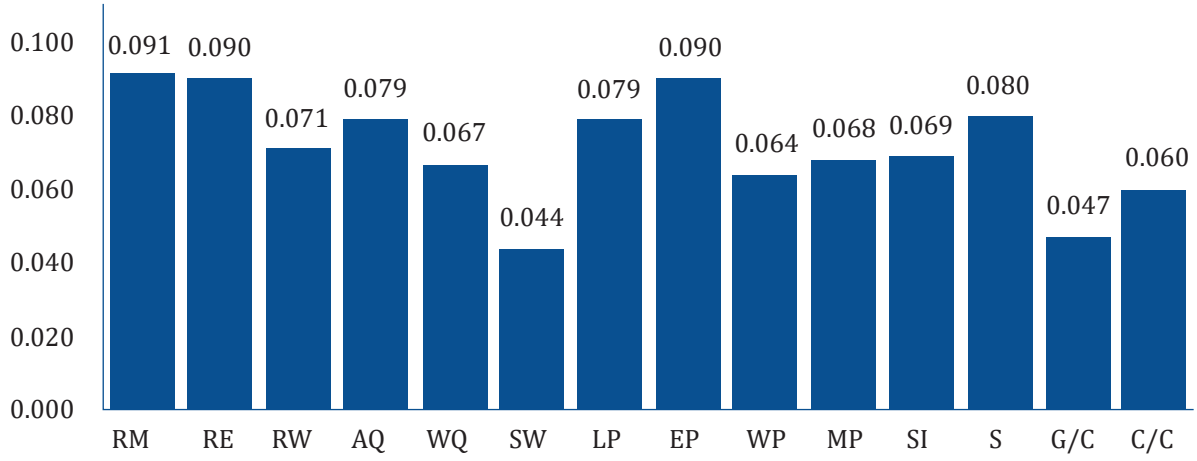

Figure 7. Final weight and order of group 1 (India, Indonesia and Philippines)

The outcome of an analysis of group 2, in which Thailand, ROK and ROC are included, is shown in Table 8 and Figure 8 below.

Table 8. Relative importance and order by criteria for group 2 (ROC, ROK and Thailand)

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.591 (1)	0.398 (2)	Raw material	0.318 (2)	0.075 (5)
				Renewable energy	0.397 (1)	0.093 (3)
				Reclaimed water	0.285 (3)	0.067 (8)
	Detoxification		0.602 (1)	Air quality	0.444 (1)	0.158 (1)
				Water quality	0.366 (2)	0.130 (2)
				Solid waste	0.190 (3)	0.068 (7)
Productivity		0.223 (2)		Labor productivity	0.268 (2)	0.060 (9)
				Energy productivity	0.320 (1)	0.071 (6)
				Water productivity	0.226 (3)	0.050 (10)
				Material productivity	0.186 (4)	0.041 (11)
Social contribution		0.186 (3)		Social investment	0.201 (2)	0.037 (12)
				Safety (health)	0.431 (1)	0.080 (4)
				Green label / certification	0.179 (4)	0.033 (14)
				Customer / consumer	0.189 (3)	0.035 (13)

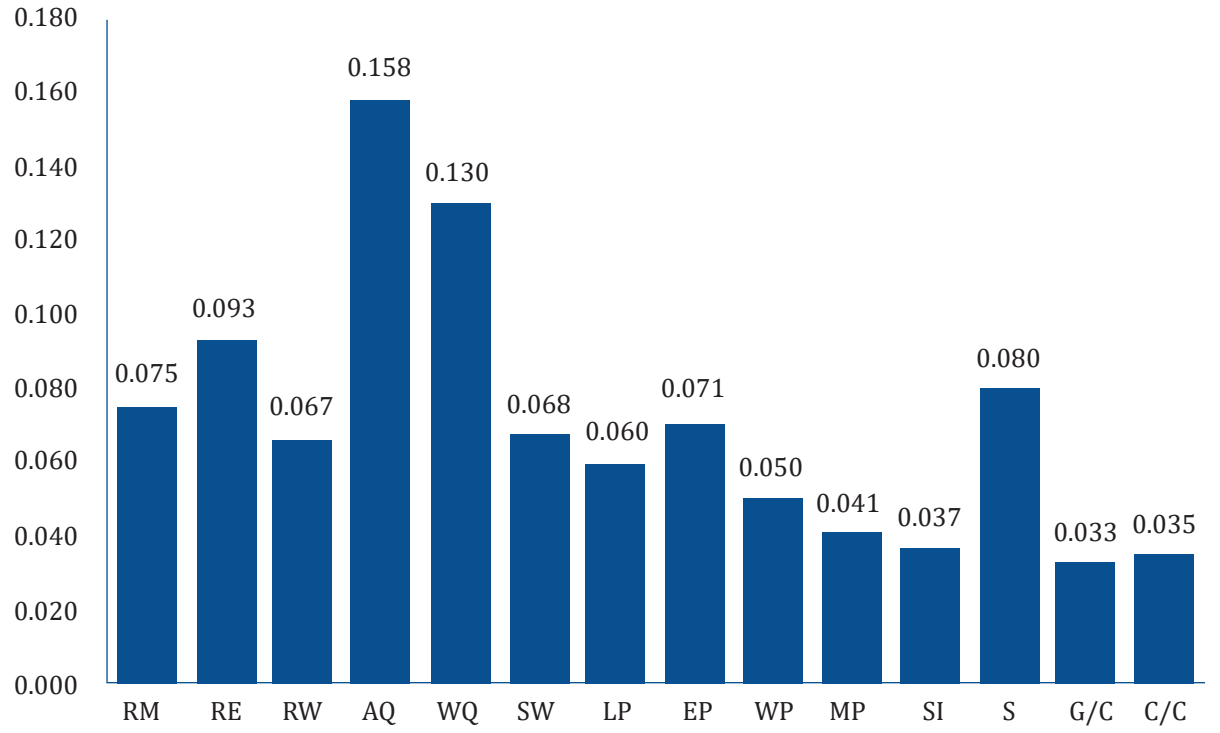

Figure 8. Final weight and order of group 2 (ROC, ROK and Thailand)

As shown in Table 7 and Table 8, environmental sustainability was the most important element in the evaluation of GB, ahead of productivity, and social contribution, for both the groups of countries. However, the weighting values in relative importance differ significantly from criteria to criterion. In the criterion of environmental sustainability, the weighting value (0.591) for the second group of countries is higher than the weighting value (0.442) for the first group of countries. Likewise, in the criteria of productivity, the weighting value (0.302) for the first group of countries is higher than the weighting value (0.223) for the second group of countries. This result implies that the economically less developed countries in Asia put relatively more focus on productivity than on environmental aspects, as compared with the economically more developed countries.

An interesting point discovered in the analysis is that the first group gives higher value (0.256) to social contribution than the second group (0.186). It may be assumed that the first group countries accord more importance to social aspects of business in consideration of productivity enhancement.

For the environmental sustainability aspects, there is a greater priority for dematerialization (0.572) over detoxification (0.428) in the first group of countries, while there is a lower priority for dematerialization (0.398) than detoxification (0.602) in the second group of countries.

The study simulated all the cases in the six countries by all criteria in detail. The specific results of analysis for each country is shown in Annex 3.

OUTCOME OF ANALYSIS 2

ANALYSIS OF OVERALL COMPANIES

In the second survey, survey participants (companies) were asked to give specific and objective value to each criterion (see Annex 2). All values surveyed by criteria and by company were transformed into values of SAW (see Equations 4 and 5). Equation 4 is applied to the positive criteria in GB, while Equation 5 is applied to the negative criteria.

The first case comprises raw material (RM), renewable energy (RE), reclaimed water (RW), labor productivity (LP), energy productivity (EP), water productivity (WP), material productivity (MP); SI (social investment), G/C (green label/certification, and C/C (customer/consumer). The latter case includes air quality (AQ), water quality (WQ), solid waste (SW), and safety (S).

All values for 89 companies across the six countries by each criterion are calculated by the SAW method and added into the four groups of dematerialization, detoxification, productivity and social contribution. Table 9 shows these SAW values by each group of criterion. In the table, eight companies of Indonesia are denoted by codes EC1…to EC8; 30 companies of India by codes IC1…to IC30; 13 companies of the Philippines by PC1...to PC13, seven companies of SOK by KC1...to KC7; 16 companies of Thailand by TC1...TC16; and 15 companies of ROC by CC1…to CC15. (See Annex 5 for detailed values for 89 companies transformed by the second-tier criteria, using SAW.)

Table 9. Survey 2 data (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution
EC1	0.057	2	0.098	2.046
EC2	0.021	0	0	3
EC3	1.212	2	0	2.046
EC4	0.168	0	0	2.864
EC5	0	1	0	2.455
EC6	0.211	1	0	2.182
EC7	0.289	2	0	2.139
EC8	0.099	0	0	1
IC1	0.185	0	0.012	2.146
IC2	0.136	0	0.002	1.319
IC3	0.181	0	0.003	2.138
IC4	0.443	0	0	2.139
IC5	0.141	0.009	0	1.091
IC6	0.172	0	0	2.094
IC7	0.047	1	0	2.186
IC8	0.142	1	0	2.185
IC9	0.112	1	0	2.093

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Companies	Dematerialization	Detoxification	Productivity	Social contribution
IC10	0.165	2	0	2.137
IC11	0.167	1	0	2.182
IC12	0.4	2	0	1
IC13	0.047	1	0	1
IC14	0.089	1	0.001	2.093
IC15	0.451	1	0	2.091
IC16	0.655	2	0	2.273
IC17	0.2	0.035	0	1
IC18	0	2	0	1
IC19	0.01	0	0.003	2.188
IC20	1.049	1	0	2.094
IC21	0.575	1	0	2.057
IC22	0.004	2	0.001	2.091
IC23	0.048	2.003	0	2.091
IC24	0.156	1	0	2.14
IC25	0.19	1	0.001	1
IC26	0.54	2	0	2.045
IC27	0.16	1	0	2.187
IC28	0.172	1	0	0
IC29	0.539	2	0	2.045
IC30	0.553	1	0.002	2.092
PC1	0.4	2	0	2.258
PC2	0	2	0	1
PC3	0.002	2	0	1.045
PC4	0	2	0	1
PC5	0	2	0	0.045
PC6	0	1	0	1.045
PC7	1	2	0	1.045
PC8	0	2	0	1.045
PC9	0	2	0	1.045
PC10	0.004	2	0	1
PC11	0	2	0.016	0.045
PC12	0.001	2	0	0
PC13	0	2	0	0
KC1	0.154	2	1.217	0.004
KC2	0.007	2	0.246	0
KC3	0.081	1	0	1.048
KC4	0.385	2	0.011	0.062
KC5	0	2	0.045	0.013

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Companies	Dematerialization	Detoxification	Productivity	Social contribution
KC6	0	2	0.493	1.078
KC7	0	2	0.919	0
TC1	0.047	2	0.025	2.045
TC2	0	1	0.008	0
TC3	0	1.001	0	1
TC4	0.097	1	0	1
TC5	0	1.001	0	1
TC6	0.412	1	0.001	1
TC7	0	1	0	1
TC8	0	1	0	1
TC9	0	1	0	1
TC10	0	1	0	1
TC11	0.128	1	0	1
TC12	0	1	0	2
TC13	0.884	1	0	2.046
TC14	0.05	1	0	2
TC15	0.789	1	0	2
TC16	0	1	0	2
CC1	0	2	0	0
CC2	0	2	0	1
CC3	0	0	3	2
CC4	0.311	0	0.043	2.003
CC5	1.648	2	0.455	2.046
CC6	0	0	0	2
CC7	0.2	2	0	1
CC8	0.06	2	0.929	2
CC9	0.249	0.003	0.616	2.227
CC10	0	2	0	1
CC11	0.075	0	0.011	2.003
CC12	0	2	0.001	2.045
CC13	0.072	3	0	1
CC14	0	2.015	0.016	1
CC15	0.85	2	0.002	2

Table 10 shows ranks of 89 companies from the six countries in GB. All values, by each criterion and by each company, come from the combination of final weights drawn from Table 6 and the corresponding values transformed by SAW in Annexure 5. However, a direct combination of Table 6 and Table 9 cannot make Table 10, since Table 9 is made by simply adding specific SAW values in second-tier criteria of Annex 5. For each country,

values by criteria are summed, which means that all companies are ranked by each sum from the best company to the worst company in GB.

Company CC5 of the ROC is awarded as the best company in the APO GP Award program. In this way, EC3 of Indonesia and CC15 of ROC win the award as the second- and third-best companies in the APO GP program. Figure 8 shows the list of highly ranked companies from CC5 to IC22.

Table 10. Relative importance and order in GB of 89 companies in six countries

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
EC1	0.005	0.244	0.005	0.124	0.378	12
EC2	0.002	0.001	0	0.16	0.163	75
EC3	0.09	0.244	0.001	0.124	0.459	2
EC4	0.014	0.001	0.001	0.155	0.171	73
EC5	0	0.134	0	0.139	0.273	44
EC6	0.017	0.134	0.001	0.129	0.281	40
EC7	0.023	0.244	0	0.128	0.395	10
EC8	0.007	0.001	0	0.045	0.053	89
IC1	0.014	0.001	0.001	0.128	0.144	78
IC2	0.01	0.001	0.001	0.054	0.066	87
IC3	0.014	0.001	0.001	0.128	0.144	78
IC4	0.035	0.001	0.001	0.128	0.165	74
IC5	0.01	0.001	0.001	0.045	0.057	88
IC6	0.013	0.001	0.001	0.126	0.141	80
IC7	0.005	0.111	0.001	0.13	0.247	55
IC8	0.012	0.111	0.001	0.129	0.253	52
IC9	0.009	0.134	0.001	0.126	0.27	45
IC10	0.013	0.244	0.001	0.128	0.386	11
IC11	0.014	0.111	0.001	0.129	0.255	51
IC12	0.028	0.244	0.001	0.081	0.354	19
IC13	0.004	0.111	0.001	0.081	0.197	65
IC14	0.008	0.134	0.001	0.126	0.269	46
IC15	0.032	0.134	0.001	0.126	0.293	35
IC16	0.056	0.244	0.001	0.133	0.434	5
IC17	0.014	0.003	0.001	0.081	0.099	86
IC18	0	0.244	0.001	0.081	0.326	27
IC19	0.001	0.001	0.001	0.13	0.133	82
IC20	0.096	0.134	0.001	0.126	0.357	17
IC21	0.042	0.134	0.001	0.125	0.302	33
IC22	0.001	0.244	0.001	0.126	0.372	15
IC23	0.004	0.244	0	0.126	0.374	13
IC24	0.012	0.134	0.001	0.128	0.275	43

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Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
IC25	0.014	0.111	0.001	0.081	0.207	63
IC26	0.038	0.244	0.001	0.124	0.407	8
IC27	0.012	0.134	0.001	0.13	0.277	42
IC28	0.013	0.111	0.001	0.001	0.126	84
IC29	0.038	0.244	0.001	0.124	0.407	8
IC30	0.04	0.134	0.001	0.126	0.301	34
PC1	0.038	0.244	0.001	0.133	0.416	6
PC2	0	0.244	0.001	0.042	0.287	38
PC3	0.001	0.244	0.001	0.083	0.329	23
PC4	0	0.244	0	0.081	0.325	29
PC5	0	0.244	0.001	0.002	0.247	55
PC6	0.001	0.134	0.001	0.083	0.219	60
PC7	0.082	0.244	0	0.083	0.409	7
PC8	0	0.244	0.001	0.083	0.328	24
PC9	0	0.244	0	0.083	0.327	25
PC10	0.001	0.244	0.001	0.081	0.327	25
PC11	0	0.244	0.002	0.002	0.248	53
PC12	0.001	0.244	0	0	0.245	57
PC13	0	0.244	0	0	0.244	58
KC1	0.011	0.244	0.09	0.001	0.346	20
KC2	0.001	0.244	0.019	0.001	0.265	47
KC3	0.006	0.111	0.001	0.044	0.162	76
KC4	0.031	0.244	0.001	0.003	0.279	41
KC5	0	0.244	0.003	0.001	0.248	53
KC6	0	0.244	0.037	0.045	0.326	28
KC7	0	0.244	0.07	0.001	0.315	31
TC1	0.004	0.244	0.002	0.124	0.374	13
TC2	0	0.134	0.001	0	0.135	81
TC3	0	0.134	0.001	0.081	0.216	62
TC4	0.01	0.134	0.001	0.042	0.187	67
TC5	0	0.134	0.001	0.042	0.177	68
TC6	0.04	0.134	0.001	0.042	0.217	61
TC7	0	0.134	0.001	0.042	0.177	68
TC8	0	0.134	0.001	0.042	0.177	68
TC9	0	0.134	0.001	0.042	0.177	68
TC10	0	0.134	0.001	0.042	0.177	68
TC11	0.013	0.134	0.001	0.042	0.19	66
TC12	0	0.134	0.001	0.123	0.258	49

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Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
TC13	0.084	0.134	0.001	0.124	0.343	21
TC14	0.005	0.134	0.001	0.123	0.263	48
TC15	0.075	0.134	0.001	0.123	0.333	22
TC16	0	0.134	0.001	0.123	0.258	49
CC1	0	0.244	0	0	0.244	58
CC2	0	0.244	0	0.042	0.286	39
CC3	0	0.001	0.169	0.123	0.293	35
CC4	0.022	0.001	0.003	0.123	0.149	77
CC5	0.141	0.244	0.036	0.124	0.545	1
CC6	0	0	0	0.123	0.123	85
CC7	0.019	0.244	0.001	0.042	0.306	32
CC8	0.005	0.244	0.072	0.123	0.444	4
CC9	0.019	0.001	0.048	0.131	0.199	64
CC10	0	0.244	0	0.081	0.325	29
CC11	0.006	0.001	0.001	0.123	0.131	83
CC12	0	0.244	0.001	0.124	0.369	16
CC13	0.007	0.305	0.001	0.042	0.355	18
CC14	0	0.245	0.002	0.042	0.289	37
CC15	0.081	0.244	0.001	0.123	0.449	3

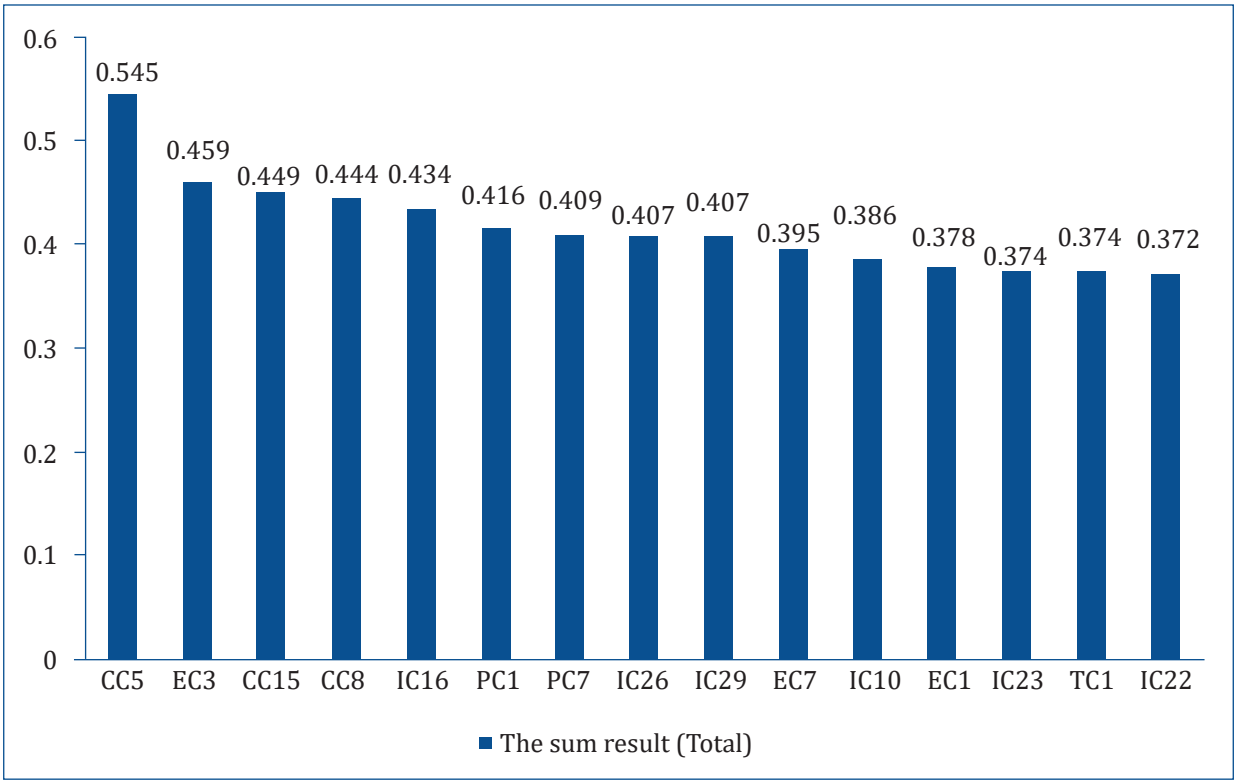

Figure 9. Rank of companies

ANALYSIS OF COMPANIES BY COUNTRY GROUPS

In order to have another way of awarding, 89 companies from the six countries can be divided into two groups as in case of Survey 1. The first group consists of Indonesia, India and the Philippines, while the second group comprises the ROK, Thailand and the ROC.

Table 11 shows the SAW values by each group of criteria in group 1 countries. The method of calculation is the same as with the case of all 89 companies. However, due to the different groups of companies, values of dematerialization, detoxification, productivity and social contribution in the four groups are different, when compared with Table 9, even for the same company.

Table 11. Survey 2 data (transformed by SAW) in group 1

Companies	Dematerialization	Detoxification	Productivity	Social contribution
EC4	0.175	0	0.062	2.864
EC5	0	1.001	0	2.455
EC6	0.22	1	0	2.182
EC7	0.298	2	0	2.139
EC8	0.099	0	0	1
IC1	0.187	0	1.052	2.146
IC2	0.138	0	0.194	1.319
IC3	0.183	0	0.223	2.138
IC4	0.459	0	0.001	2.139
IC5	0.141	0.243	0.03	1.091
IC6	0.176	0	0.013	2.094
IC7	0.051	1	0.002	2.186
IC8	0.149	1	0.01	2.185
IC9	0.112	1	0.019	2.093
IC10	0.167	2	0.017	2.137
IC11	0.177	1	0.018	2.182
IC12	0.4	2	0.005	1
IC13	0.047	1	0.003	1
IC14	0.094	1	0.089	2.093
IC15	0.451	1.002	0.005	2.091
IC16	0.698	2	0.001	2.273
IC17	0.2	1	0	1
IC18	0	2	0.001	1
IC19	0.011	0	1.003	2.188
IC20	1.149	1	0.008	2.094
IC21	0.58	1	0.064	2.057

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Companies	Dematerialization	Detoxification	Productivity	Social contribution
IC22	0.004	2.002	0.208	2.091
IC23	0.048	2.085	0	2.091
IC24	0.161	1	0.006	2.14
IC25	0.19	1	0.379	1
IC26	0.54	2	0.001	2.045
IC27	0.163	1	0.003	2.187
IC28	0.172	1	0.001	0
IC29	0.539	2	0.001	2.045
IC30	0.557	1	0.154	2.092
PC1	0.445	2	0.007	2.258
PC2	0	2	0.021	1
PC3	0.002	2	0.028	1.045
PC4	0	2	0	1
PC5	0	2.002	0.022	0.045
PC6	0	1.007	0.003	1.045
PC7	1	2.001	0	1.045
PC8	0	2	0	1.045
PC9	0	2.009	0	1.045
PC10	0.004	2	0.049	1
PC11	0	2.004	1.004	0.045
PC12	0.001	2	0	0
PC13	0	2	0	0

Table 12 shows ranks of 51 companies from three countries in GB. All values, by each criterion, and by each company come from the combination of final weights from Table 7, with the corresponding values transformed by SAW in Annex 5.

As shown in Table 12, EC6 of Indonesia can be awarded as the number one company in the APO Group 1 GP Award program. In this way, EC4 of Indonesia and IC19 of India can win the second and third awards in group 1. Figure 9 shows the list of highly ranked companies in the country group 1.

Table 12. Relative importance and order in GB in group 1

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
EC4	0.004	0.145	0.073	0.142	0.364	2
EC5	0.002	0	0	0.187	0.189	37
EC6	0.092	0.145	0.01	0.142	0.389	1
EC7	0.014	0	0.005	0.18	0.199	35
EC8	0	0.079	0	0.161	0.24	18

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Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
IC1	0.018	0.079	0	0.148	0.245	17
IC2	0.023	0.145	0	0.146	0.314	9
IC3	0.007	0	0	0.069	0.076	48
IC4	0.014	0	0.068	0.147	0.229	26
IC5	0.01	0	0.013	0.075	0.098	45
IC6	0.013	0	0.015	0.146	0.174	39
IC7	0.036	0	0	0.146	0.182	38
IC8	0.01	0.011	0.002	0.064	0.087	46
IC9	0.013	0	0.001	0.144	0.158	41
IC10	0.005	0.067	0	0.148	0.22	33
IC11	0.012	0.067	0.001	0.148	0.228	28
IC12	0.008	0.079	0.002	0.144	0.233	22
IC13	0.012	0.145	0.001	0.146	0.304	11
IC14	0.015	0.067	0.001	0.148	0.231	23
IC15	0.028	0.145	0	0.08	0.253	16
IC16	0.003	0.067	0	0.08	0.15	42
IC17	0.008	0.079	0.007	0.144	0.238	20
IC18	0.032	0.079	0	0.144	0.255	15
IC19	0.058	0.145	0	0.152	0.355	3
IC20	0.014	0.044	0	0.08	0.138	44
IC21	0	0.145	0	0.08	0.225	31
IC22	0.001	0	0.08	0.149	0.23	24
IC23	0.101	0.079	0.001	0.144	0.325	5
IC24	0.042	0.079	0.005	0.143	0.269	14
IC25	0	0.145	0.016	0.144	0.305	10
IC26	0.004	0.149	0	0.144	0.297	12
IC27	0.012	0.079	0	0.146	0.237	21
IC28	0.014	0.067	0.03	0.08	0.191	36
IC29	0.038	0.145	0	0.142	0.325	5
IC30	0.012	0.079	0	0.149	0.24	18
PC1	0.012	0.067	0	0	0.079	47
PC2	0.038	0.145	0	0.142	0.325	5
PC3	0.04	0.079	0.01	0.144	0.273	13
PC4	0.04	0.145	0.001	0.153	0.339	4
PC5	0	0.145	0.002	0.06	0.207	34
PC6	0	0.145	0.003	0.082	0.23	24
PC7	0	0.145	0	0.08	0.225	31
PC8	0	0.146	0.002	0.002	0.15	43
PC9	0	0.079	0	0.082	0.161	40

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Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
PC10	0.091	0.145	0	0.082	0.318	8
PC11	0	0.145	0	0.082	0.227	30
PC12	0	0.146	0	0.082	0.228	28
PC13	0	0.145	0.004	0.08	0.229	26

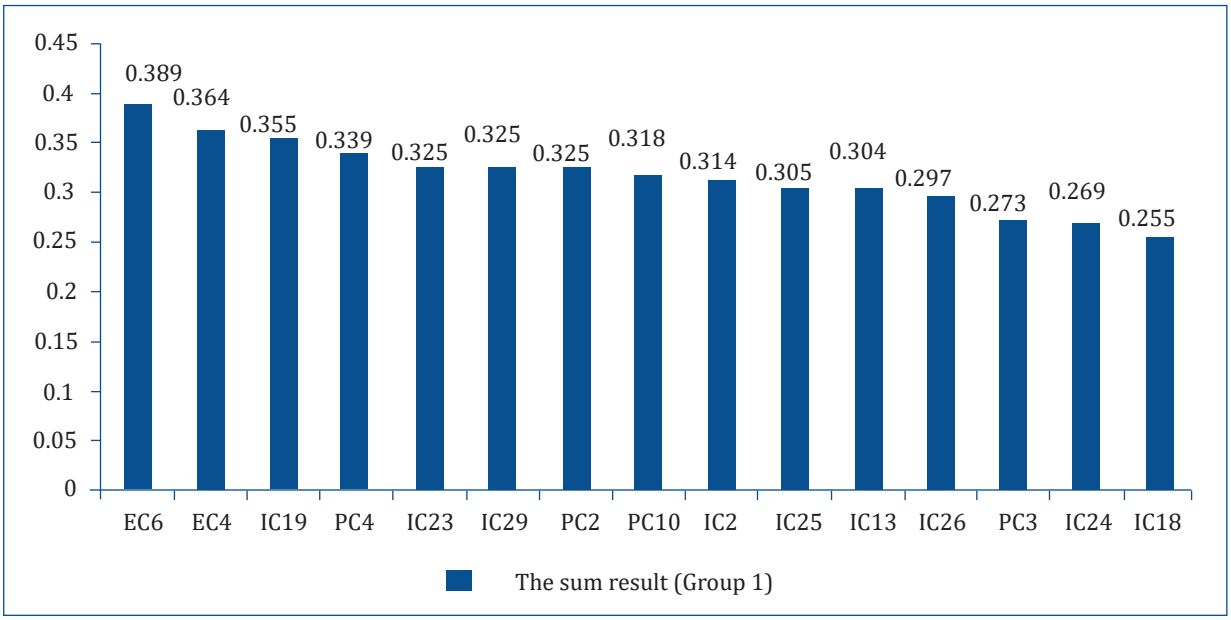

Figure 10. Rank of companies in country group 1

Table 13 shows the SAW values by each group of criteria in group 2 countries. The method of calculation is the same as with the case of all 89 companies.

Table 13 Survey 2 data (transformed by SAW) in group 2

Companies	Dematerialization	Detoxification	Productivity	Social contribution
KC1	0.256	2	1.217	0.117
KC2	0.151	2	0.246	0
KC3	0.135	1	0	1.278
KC4	0.691	2	0.011	0.703
KC5	0	2	0.045	0.386
KC6	0	2	0.493	2.2
KC7	0	2	0.919	0
TC1	0.079	2	0.025	2.2
TC2	0	1	0.008	0
TC3	0	1.001	0	1
TC4	0.097	1	0	1

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Companies	Dematerialization	Detoxification	Productivity	Social contribution
TC5	0	1.001	0	1
TC6	0.412	1	0.001	1.001
TC7	0	1	0	1
TC8	0	1	0	1
TC9	0	1	0	1.001
TC10	0	1	0	1.001
TC11	0.128	1	0	1
TC12	0	1	0	2
TC13	0.884	1	0	2.202
TC14	0.05	1	0	2
TC15	0.789	1	0	2
TC16	0	1	0	2.002
CC1	0	2	0	0
CC2	0	2	0	1
CC3	0	0	3	2.014
CC4	0.969	0	0.043	2.104
CC5	3	2	0.455	2.227
CC6	0	0	0	2
CC7	0.2	2	0	1
CC8	0.08	2	0.929	2.001
CC9	0.77	0.003	0.616	3.005
CC10	0	2	0	1
CC11	0.128	0	0.011	2.083
CC12	0	2	0.001	2.2
CC13	0.462	3	0	1
CC14	0	2.015	0.016	1
CC15	0.85	2	0.002	2

Table 14 shows ranks of 31 companies from three countries in GB. All values, by each criteria, and by each company, come from the combination of final weights from Table 8 and the corresponding values transformed by SAW in Annex 5.

As shown in Table 14, CC5 of the ROC is the best company in the APO country group 2. In this way, CC15 and CC8 of the ROC can win the award as second- and third-best companies, respectively, in group 1. Figure 11 shows the list of highly ranked companies in the country group 2.

Table 14. Relative importance and order in GB in group 2

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
KC1	0.017	0.288	0.082	0.004	0.391	8
KC2	0.011	0.288	0.017	0	0.316	17
KC3	0.009	0.13	0	0.045	0.184	35
KC4	0.051	0.288	0.001	0.025	0.365	10
KC5	0	0.288	0.003	0.014	0.305	18
KC6	0	0.288	0.033	0.079	0.4	7
KC7	0	0.288	0.064	0	0.352	12
TC1	0.005	0.288	0.002	0.122	0.417	5
TC2	0	0.158	0.001	0	0.159	36
TC3	0	0.158	0	0.08	0.238	25
TC4	0.009	0.158	0	0.035	0.202	28
TC5	0	0.158	0	0.035	0.193	29
TC6	0.038	0.158	0	0.035	0.231	26
TC7	0	0.158	0	0.035	0.193	29
TC8	0	0.158	0	0.035	0.193	29
TC9	0	0.158	0	0.035	0.193	29
TC10	0	0.158	0	0.035	0.193	29
TC11	0.012	0.158	0	0.035	0.205	27
TC12	0	0.158	0	0.115	0.273	21
TC13	0.082	0.158	0	0.122	0.362	11
TC14	0.005	0.158	0	0.115	0.278	20
TC15	0.074	0.158	0	0.115	0.347	13
TC16	0	0.158	0	0.115	0.273	21
CC1	0	0.288	0	0	0.288	19
CC2	0	0.288	0	0.035	0.323	16
CC3	0	0	0.151	0.116	0.267	23
CC4	0.069	0	0.002	0.119	0.19	34
CC5	0.235	0.288	0.032	0.123	0.678	1
CC6	0	0	0	0.115	0.115	38
CC7	0.019	0.288	0	0.035	0.342	14
CC8	0.006	0.288	0.066	0.115	0.475	3
CC9	0.055	0	0.044	0.149	0.248	24
CC10	0	0.288	0	0.08	0.368	9
CC11	0.009	0	0.001	0.118	0.128	37
CC12	0	0.288	0	0.122	0.41	6
CC13	0.035	0.356	0	0.035	0.426	4
CC14	0	0.289	0.001	0.035	0.325	15
CC15	0.079	0.288	0	0.115	0.482	2

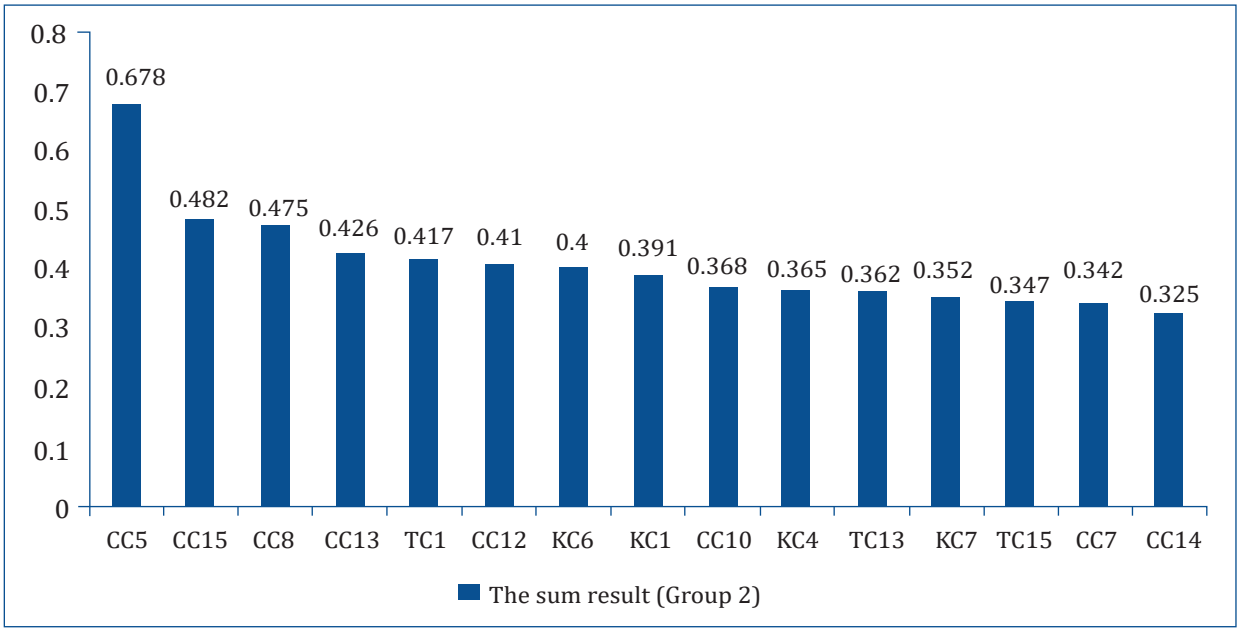

Figure 11. Rank of companies in country group 2

ANALYSIS OF COMPANIES BY COMPANY SCALES

In order to evaluate companies by their scales, the 89 companies are sorted by their production levels. Table 15 shows the large-scale companies listed vertically, starting with the largest company at the top and the 44th largest company at the bottom. Table 16 lists the small-scale companies, starting with the 45th largest company at the top and the smallest of the 89 companies stacked toward the bottom. Sum of SAW values for each company comes from Table 12, and its rank by that sum is also shown in Table 15 or Table 16.

As shown in Table 15, CC5 of the ROC is the best company in the APO large-scale group. In this way, EC3 of Indonesia, and CC8 of the ROC can win the award as second- and third-best companies in the large-scale company group. Figure 12 shows the list of highly ranked companies in the large-scale company group.

Table 15. Relative importance and order in GB in the large-scale group

Companies	Labor productivity	Rank of labor productivity	Sum	Rank of Sum
CC3	500,000,000	1	0.293	19
KC5	22,419,166	2	0.248	29
CC11	4,470,000	3	0.131	43
CC4	3,980,618	4	0.149	39
CC5	2,700,000	5	0.545	1
IC19	1,706,732	6	0.133	42
IC25	614,766	7	0.207	31
CC12	450,000	8	0.369	8

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Companies	Labor productivity	Rank of labor productivity	Sum	Rank of Sum
IC22	329,080	9	0.372	7
EC3	220,000	10	0.459	2
KC4	150,833	11	0.279	21
IC14	139,111	12	0.269	23
KC1	125,000	13	0.346	11
EC4	104,932	14	0.171	37
CC9	100,000	15	0.199	32
EC1	90,095	16	0.378	5
TC4	73,532	17	0.187	33
IC21	73,295	18	0.302	17
IC1	68,362	19	0.144	40
TC7	63,259	20	0.177	34
CC13	50,782	21	0.355	10
KC6	48,333	22	0.326	15
TC1	47,152	23	0.374	6
IC3	46,220	24	0.144	40
TC12	44,119	25	0.258	25
TC13	39,392	26	0.343	12
IC2	38,741	27	0.066	44
PC10	36,868	28	0.327	14
TC15	36,389	29	0.333	13
KC3	35,000	30	0.162	38
IC30	32,908	31	0.301	18
IC9	31,861	32	0.27	22
KC7	31,667	33	0.315	16
CC8	30,000	34	0.444	3
IC11	29,766	35	0.255	27
PC2	24,343	36	0.287	20
PC5	20,414	37	0.247	30
TC9	19,982	38	0.177	34
KC2	19,167	39	0.265	24
IC8	17,052	40	0.253	28
TC16	12,727	41	0.258	25
PC1	12,373	42	0.416	4
IC20	12,116	43	0.357	9
TC8	10,698	44	0.177	34

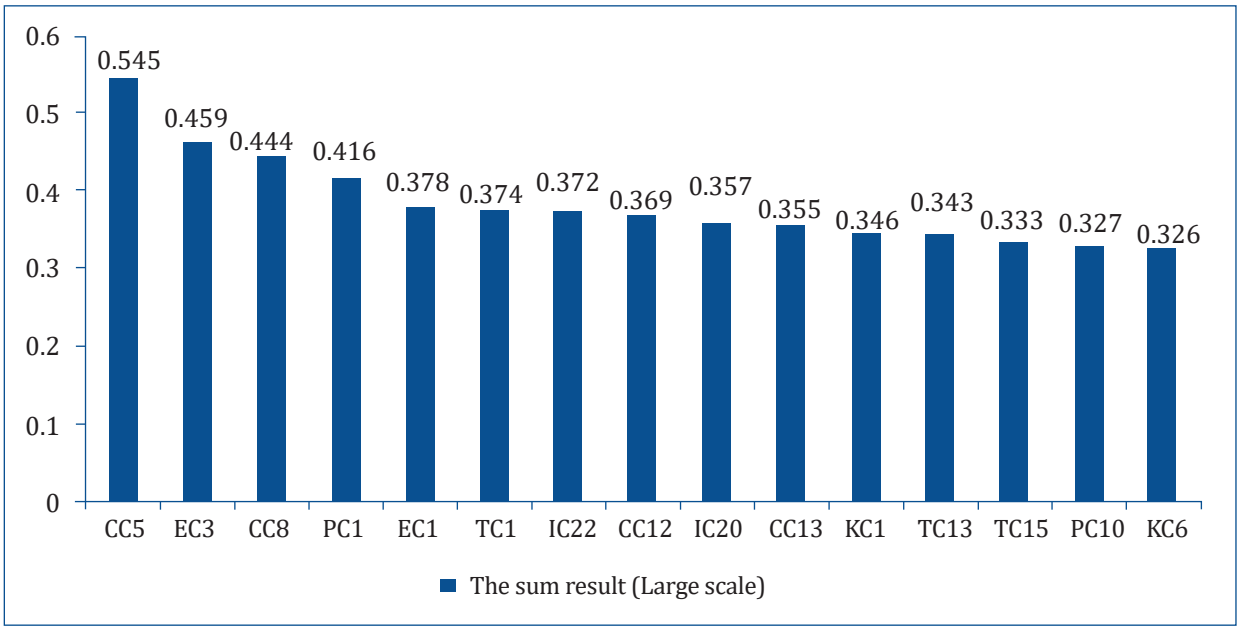

Figure 12. Rank of companies in the large-scale group

As shown in Table 16, CC15 of the ROC is the best company in the APO Small-scale Group Award program. In this way, 1C15 of India and PC7 of the Philippines can win the award as the second- and third-best companies in the APO small-scale company group. Figure 13 shows the list of highly ranked companies in the small-scale company group from CC15 to CC10.

Table 16. Relative importance and order in GB in the small-scale group

Companies	Labor productivity	Rank of labor productivity	Sum	Rank of Sum
IC5	9,972	45	0.057	44
IC6	9,124	46	0.141	39
PC11	7,272	47	0.248	25
TC5	7,035	48	0.177	35
IC24	6,189	49	0.275	22
TC6	6,128	50	0.217	31
IC10	6,058	51	0.386	7
TC2	5,515	52	0.135	40
TC3	4,963	53	0.216	32
TC11	4,812	54	0.19	34
IC27	4,487	55	0.277	21
IC13	4,427	56	0.197	33
TC10	4,308	57	0.177	35
IC12	3,889	58	0.354	9
TC14	3,116	59	0.263	24

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Companies	Labor productivity	Rank of labor productivity	Sum	Rank of Sum
IC7	3,021	60	0.247	26
IC4	1,750	61	0.165	37
IC16	1,705	62	0.434	2
IC29	1,585	63	0.407	4
IC26	1,406	64	0.407	4
IC28	1,091	65	0.126	41
IC15	1,076	66	0.293	17
CC15	500	67	0.449	1
CC14	250	68	0.289	18
IC17	90	69	0.099	43
PC8	43	70	0.328	11
IC18	25	71	0.326	13
CC7	20	72	0.306	16
EC6	3	73	0.281	20
EC2	0	74	0.163	38
EC5	0	74	0.273	23
EC7	0	74	0.395	6
EC8	0	74	0.053	45
IC23	0	74	0.374	8
PC3	0	74	0.329	10
PC4	0	74	0.325	14
PC6	0	74	0.219	30
PC7	0	74	0.409	3
PC9	0	74	0.327	12
PC12	0	74	0.245	27
PC13	0	74	0.244	28
CC1	0	74	0.244	28
CC2	0	74	0.286	19
CC6	0	74	0.123	42
CC10	0	74	0.325	14

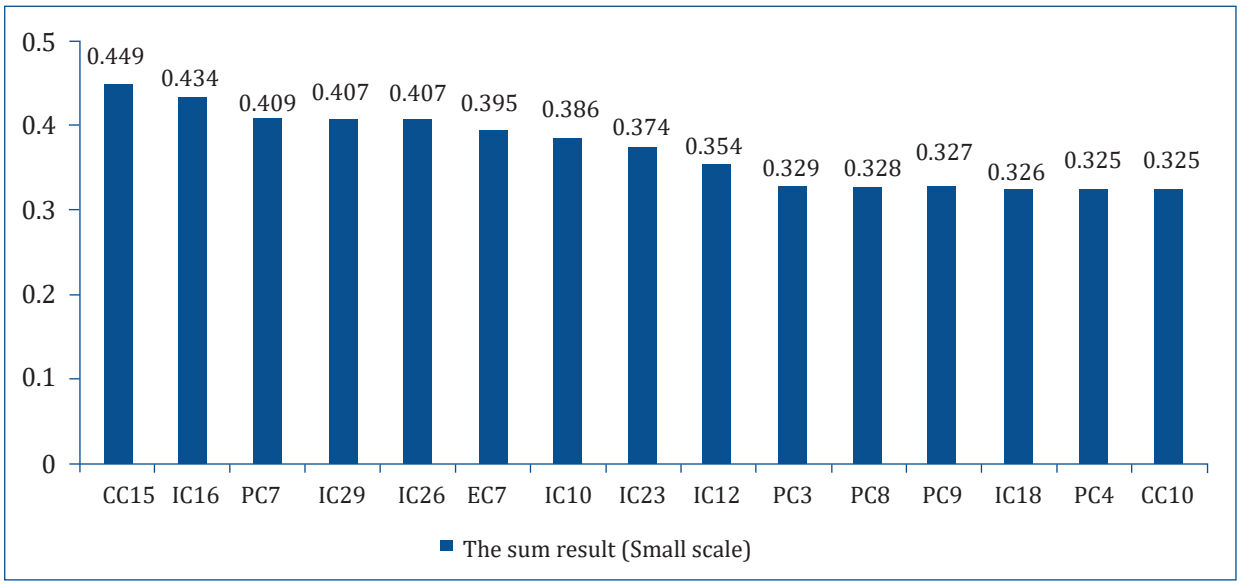

Figure 13. Rank of companies in the small-scale group

CONCLUSION

The study was planned to review the status of green business (GB) in APO member countries. In order to monitor and evaluate the effectiveness and performance of GB, the research reviewed various methods and indicators currently used to assess GB, and established a framework with a set of indicators to rate green companies in the region.

In order to include a diverse set of criteria, the multi-criteria decision making (MCDM) method was adopted. And in order to evaluate these criteria, the analytic hierarchy process (AHP) was introduced, and pairwise comparison was performed to drive relative importance among all criteria.

The main framework basically has two tiers of each criterion. Environmental sustainability, productivity and social contribution are the criteria in the first tier under which 14 specific criteria are used in the second tier. In the case of environmental sustainability, two specific sub-criteria of dematerialization and detoxification in the first tier are additionally used to cover diverse elements of environmental issue.

The survey was conducted through two stages: Survey 1 was to collect pairwise comparison data in each criterion from 367 respondents by country; while Survey 2 was to collect direct and objective data from candidate companies, also by country. Based on Survey 1, the study derived relative importance of all criteria using the AHP simulation technique. Then, the study comparatively evaluated 89 companies for their respective performances in GP, while considering relative importance of all criteria.

In the simulation result of Survey 1, the highest relative importance among the three first-tier criteria across the six Asian countries was environmental sustainability (0.550), followed by productivity (0.245) and social contribution (0.204). Within the environmental sustainability aspect, the sub-category detoxification (0.554) recorded a priority over the other sub-category dematerialization (0.446). The study additionally conducted analysis, both by country and by group, which showed similar results in general.

A total of 89 companies from six countries were analyzed in the second stage of analysis. All companies were ranked by sum of values for each criterion. The SAW method was used in the transformation of all original values into comparable values. The company CC5 from ROC got the highest value (0.545) in the APO GP program. The other companies with notably high scores were EC3 (0.459), CC15 (0.449), CC8 (0.444), IC16 (0.434), and PC1 (0.416).

The study divided 89 companies into diverse companies by country, by country groups and by size of labor productivity; and simulated all the companies in each category. In the large-scale-companies group, the other companies with high scores were CC3 (0.545), EC3 (0.459), CC8 (0.444), PC1 (0.416), and EC1 (0.378). In the small-scale-companies group, the other companies with high scores were CC15 (0.449), IC16 (0.434), PC7 (0.409), IC29 (0.407), and IC26 (0.407).

The study could rank all of participating companies in term of GB, which is defined by the APO GP expert group. Based on the concept, the framework and criteria were developed in detail. The MCDM and AHP tools applied in the analysis were appropriate in evaluating the diverse criteria for GP.

If more accurate and more accumulated data in Survey 2 from companies is possible, the APO award program in GP will be successfully implemented at any time. The evaluation of framework and criteria, and its further application in larger sample sizes will also improve the applicability of GP in reality.

EVALUATION GLOSSARY (EXPLANATION OF TERMINOLOGY)

1. **Dematerialization:** It may refer to the reduction in the quantity of materials required to serve economic functions (doing more with less), or using less or no material to deliver the same level of functionality.

2. **Detoxification:** Originally, this term was mainly used in medical treatment as a metabolic process by which toxins are changed into less toxic or more readily excreted substances. Currently, this term is applied to environmental situations to describe less use of toxic substances or completely removing them from processes or products.

3. **Decarbonization: "**Fundamental decarbonization" of the world economy has been a goal for the Intergovernmental Panel on Climate Change (IPCC). It denotes the declining average carbon intensity of primary energy over time. Here de-carbonization is defined as any action or process that can reduce or completely eliminate the emissions of greenhouse gases (GHGs).

4. **General productivity:** Productivity is commonly defined as a ratio of volume measure of output to a volume of measure of input. The most commonly used measure for input is labor or capital, while output is gross output (revenue or sales) or value added. These types of productivity are referred to as general productivity in this document.

5. **Environmental productivity**: In contrast to general productivity that applies labor and capital as inputs (denominators) in expressing productivity, environmental productivity adopts concepts such as resource productivity and eco-efficiency, and uses resource consumption or environmental impact as input. In this document, one environmental impact (GHGs emissions) and three resources (material, energy, and water consumption) are used for describing environmental productivity.

6. **Green innovation (Eco-innovation)**: There are various definitions and that of the OECD (2009) was used, which states "the creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which with or without intent lead to environmental improvements compared to relevant alternatives."

7. **Sustainable innovation**: Sustainable innovation in this document is defined as any innovative product, process, or business model that a company has developed, which can solve specifically social problems and contribute to sustainable development as a whole.

8. **Ton(s) of oil equivalent (toe)**: This is a normalized unit of energy. By convention it is equivalent to the approximate amount of energy that can be extracted from one ton of crude oil. It is a standardized unit, which is assigned a net calorific value of 41,868 kilojoules/kg and may be used to compare energy from different sources.
   (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Tonnes_of_oil_equivalent_(toe))

Other energy carriers can be converted into toe using the following conversion factors, such as 1 t diesel = 1.01 toe; 1 m3 diesel = 0.98 toe; 1 t petrol = 1.05 toe; 1 m3 petrol = 0.86 toe; 1 t biodiesel = 0.86 toe; 1 m3 biodiesel = 0.78 toe; 1 t bioethanol = 0.64 toe; and 1 m3 bioethanol = 0.51 toe.

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ANNEX 1. SURVEY 1

Research on the Status of Green Business in the Region – Survey Questionnaire

Research Project Background

A green business (GB) adopts strategies that demonstrate commitment to a sustainable future. In order to monitor and evaluate the effectiveness and performance of green businesses (GBs), criteria to measure the progress of environmental performance and sustainable business are important. The APO conducts research on the status of GB in the region across the APO member economies. This research aims at studying the extent of adoption of GB in several APO member countries by developing a Green Productivity (GP) Excellence Framework through which a company's GB practices can be evaluated.

<*Since 1994, the APO has been promoting GP as a strategy for simultaneously enhancing productivity and environmental performance for overall socio-economic development that leads to sustained improvement in the quality of human life*.>

Research Framework

In February 2015, an Expert Coordination Meeting was held in Seoul, Korea. After the meeting and preliminary literature reviews, the experts came up with a framework of three important criteria for the evaluation and ranking of green business as follows:

1. Environmental sustainability
2. Productivity, and
3. Social contribution.

Questionnaire Objective

This questionnaire aimed at determining the relative importance of various criteria used to assess GB in the APO member countries. Analytic Hierarchy Process (AHP) method was adopted to calculate the importance weight of each criterion and sub-criterion. The respondents were asked to compare the relative importance of each criterion among three criteria (first trial evaluation) and specific sub-criteria in each criterion (second trial evaluation). < *Please refer to Table 1 for more details*>

The final importance weights of criteria, combined with actual data from companies, helped evaluate and rank the environmental performance of companies in the APO member economies.

If you have any questions, please do not hesitate to contact the following person:
Address and name of National Expert:
Tel:
E-mail:

What type of organization are you working in?

1. Education and research ( ) 3. Company ( )
2. Government ( ) 4. Others ( ) *Please specify*

1. Research Framework: From the Experts Coordination Meetings and based on previous literature reviews, the evaluation framework with following criteria is adopted <Table 1>

First trial evaluation criteria	Aspects	Second evaluation criteria	Definition
Environmental sustainability	Dematerialization	Raw material	Percentage of natural material consumption to total usage
		Renewable energy	Percentage of renewable energy to total energy consumption
		Reclaimed water	Percentage of reclaimed water of total natural water used
	Detoxification	Air quality	Emissions of air pollutants, including SOx, NOx, VOC and other toxics
		Water quality	Total volume of water discharged by destination (BOD, COD and other toxics)
		Solid waste	Total amount of solid waste and hazardous waste materials
Productivity	General productivity	Labor productivity	Economic value created every year per person in the labor force
		Energy productivity	Economic value created every year per unit of energy consumed
		Water productivity	Economic value created every year per unit of water consumed
		material productivity	Economic value created every year per unit of material consume
Social contribution	CSR (Corporate social responsibility)	Social investment	Amount of investment towards for contribution
		Safety (health)	Number of industrial incidence inside and outside
		Green label/ certification	Current number of label/ certification
		Customer/ consumer	Any channel for customer/ consumer number of complaints

2. Questions

Instructions to answer
If you consider environmental sustainability (criteria A) is "very strongly important" than productivity (criteria B), you check 7 or 6 as follows. Or If you think productivity (criteria B) is "slightly important" than social consideration (Criteria C), you check 2 or 3.

A	A is more important than B Very strongly, strongly, slightly						Equal	B is more important than A Slightly, strongly, very strongly						B
Environmental sustainability	7	6	5	4	3	2	1	2	3	4	5	6	7	Productivity
Social contribution	7	6	5	4	3	2	1	2	3	4	5	6	7	Productivity

Questions for first-tier evaluation criteria. Please check the relative importance of criteria by comparing each other.

A	A is more important than B Very strongly, strongly, slightly						Equal	B is more important than A Slightly, strongly, very strongly						B
Environmental sustainability	7	6	5	4	3	2	1	2	3	4	5	6	7	Productivity
Environmental sustainability	7	6	5	4	3	2	1	2	3	4	5	6	7	Social contribution
Productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Social contribution

Questions for second-tier evaluation criteria. Please check the relative importance of criteria by comparing each other

(Environmental sustainability: Dematerialization)

A	A is more important than B Very strongly, strongly, slightly						Equal	B is more important than A Slightly, strongly, very strongly						B
Raw material	7	6	5	4	3	2	1	2	3	4	5	6	7	Renewable energy
Raw material	7	6	5	4	3	2	1	2	3	4	5	6	7	Reclaimed water
Renewable energy	7	6	5	4	3	2	1	2	3	4	5	6	7	Reclaimed water

(Environmental sustainability: Detoxification)

A	A is more important than B						Equal	B is more important than A						B
	Very strongly, strongly, slightly							Slightly, strongly, very strongly						
Air quality	7	6	5	4	3	2	1	2	3	4	5	6	7	Water quality
Air quality	7	6	5	4	3	2	1	2	3	4	5	6	7	Solid waste
Water quality	7	6	5	4	3	2	1	2	3	4	5	6	7	Solid waste

(Dematerialization vs. Detoxification)

A	A is more important than B						Equal	B is more important than A						B
	Very strongly, strongly, slightly							Slightly, strongly, very strongly						
Dematerialization	7	6	5	4	3	2	1	2	3	4	5	6	7	Detoxification

(Productivity)

A	A is more important than B						Equal	B is more important than A						B
	Very strongly, strongly, slightly							Slightly, strongly, very strongly						
Labor productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Energy productivity
Labor productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Water productivity
Labor productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Material productivity
Energy productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Water productivity
Energy productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Material productivity
Water productivity	7	6	5	4	3	2	1	2	3	4	5	6	7	Material productivity

(Social contribution)

A	A is more important than B						Equal	B is more important than A						B
	Very strongly, strongly, slightly							Slightly, strongly, very strongly						
Social investment	7	6	5	4	3	2	1	2	3	4	5	6	7	Safety (health)
Social investment	7	6	5	4	3	2	1	2	3	4	5	6	7	Green label/ certification
Social investment	7	6	5	4	3	2	1	2	3	4	5	6	7	Consumer/ customer
Safety (health)	7	6	5	4	3	2	1	2	3	4	5	6	7	Green label/ certification
Safety (health)	7	6	5	4	3	2	1	2	3	4	5	6	7	Consumer/ customer
Green label/ certification	7	6	5	4	3	2	1	2	3	4	5	6	7	Consumer/ customer

Thank you for your participation!

ANNEX 2. SURVEY 2

Research on the Status of Green Business in the Region – Survey Questionnaire

Research Project Background

A green business adopts strategies that demonstrate commitment to a sustainable future. In order to monitor and evaluate the effectiveness and performance of green businesses, criteria to measure the progress of environmental performance and sustainable business are important. The APO conducts a research on the status of Green Business in the region to study the extent of adoption of green business in APO member countries by developing a GP Excellency program through which business companies in APO member countries will be evaluated in terms of GP.

<Since 1994, the APO has been promoting Green Productivity (GP) as a strategy for simultaneously enhancing productivity and environmental performance for overall socio-economic development that leads to sustained improvement in the quality of human life.>

Research Framework

In February 2015, an Expert Coordination Meeting was held in Seoul, Korea. After the meeting and preliminary literature reviews, the experts have come up with a framework of three important criteria for the evaluation and ranking of green business as follows:

1. Environmental sustainability
2. Productivity, and
3. Social contribution. *<Please refer to Table 1 for more details>*

Questionnaire Objective

The relative importance of each criterion will be determined by the other survey (survey 1) from diverse people including experts, policy makers, business man, and other citizens in APO member countries. Analytic Hierarchy Process (AHP) method will be adopted to calculate the importance weight of each criterion and sub-criterion.

This survey for the company is to collect actual data for its performance. Your reply on questions will be integrated with weighting values gained from the survey 1. The final performance evaluation and ranking of companies within this framework will help determine the status of Green Business among APO member economies.

If you have any questions, please do not hesitate to contact the following person:

Address and name of National Expert:
Tel: E-mail:

※ Evaluation Criteria and definitions <Table 1>

First trial evaluation criteria	Aspects	Second evaluation criteria	Definition
Environmental sustainability	Dematerialization	Raw material	Percentage of natural material consumption to total usage
		Renewable energy(saving)	Percentage of renewable energy (energy saving) to total energy consumption
		Reclaimed water	Percentage of reclaimed water of total natural water used
	Detoxification	Air quality	Emissions of air pollutants, including SOx, NOx, VOC and other toxics
		Water quality	Total volume of water discharged by destination (BOD, COD and other toxics)
		Solid waste	Total amount of solid waste and hazardous waste materials
Productivity	General productivity	Labor productivity	Economic value created every year per person in the labor force
		Energy productivity	Economic value created every year per unit of energy consumed
		Water productivity	Economic value created every year per unit of water consumed
		material productivity	Economic value created every year per unit of material consume
Social contribution	CSR (corporate social responsibility)	Social investment	Amount of investment towards for contribution
		Safety (health)	Number of industrial incidence inside and outside
		Green label/ certification	Current number of label/ certification
		Customer/ consumer	Any channel for customer/consumer number of complaints

General Information

Company name	
Address and contact details (name, telephone, email)	
Type of product/ service	
Total production capacity (unit/year)	
Number of employees	

1. Environmental Sustainability

Criteria	Formula	Data
(1) Dematerialization		
Raw material	Total raw material consumption (ton/year)	
	Total amount of recycled material (ton/year)	
	Total production (Overall production)	
Renewable energy (Energy saving)	Percentage of renewable energy to total energy consumption	
	Metric ton or equivalent of energy save per ton of product	
Reclaimed water	Total water consumption (unit: Unit: m^3 /year)	
	Total amount of recycled water Unit: m^3 /year	
(2) Detoxification		
Air quality	Sox, NOx, VOC (Y/N) above regulation/ law	
	Total amount of emission to air	
Water quality	BOD, COD, other toxics (Y/N) above regulation/ law	
	Total amount of waste water	
Solid waste	Total amount of solid waste Unit: Ton/year	
	Amount of hazardous waste Unit: kg/year	

2. Productivity

Criteria	Formula	Data
Labor productivity	Production (value added/total employees (y)	
Energy productivity	Production (value added/energy consumption (y)	
Water productivity	Production (value added/water consumption (y)	
Material productivity	Production (value added/ material consumption (y)	

3. **Social Contribution**

Criteria	Formula	Data
Social investment	Amount of investment towards for social contribution (money/year)	
	Number of employees and time spent for social service	
Safety (health)	Number of industrial incidence inside and outside (no/year)	
	List of safety and health measure implemented/ practiced	
Green label and certification	Current number of label/ certification	
Customer and consumer	Any channel for Customer/ consumer (Y/N)	
	Number of complaints	

Thank you for your participation!

ANNEX 3. RELATIVE IMPORTANCE OF GP CRITERIA BY COUNTRY

ROC

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.607 (1)	0.391 (2)	Raw material	0.323 (2)	0.077 (5)
				Renewable energy	0.397 (1)	0.094 (3)
				Reclaimed water	0.280 (3)	0.066 (7)
	Detoxification		0.609 (1)	Air quality	0.465 (1)	0.172 (1)
				Water quality	0.365 (2)	0.135 (2)
				Solid waste	0.170 (3)	0.063 (8)
Productivity		0.209 (2)		Labor productivity	0.262 (2)	0.055 (9)
				Energy productivity	0.319 (1)	0.067 (6)
				Water productivity	0.239 (3)	0.050 (10)
				Material productivity	0.180 (4)	0.038 (11)
Social contribution		0.184 (3)		Social investment	0.200 (2)	0.037 (12)
				Safety (health)	0.430 (1)	0.079 (4)
				Green label / certification	0.191 (3)	0.035 (13)
				Customer / consumer	0.178 (4)	0.033 (14)

India

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.441 (1)	0.692 (1)	Raw material	0.424 (1)	0.129 (1)
				Renewable energy	0.295 (2)	0.090 (3)
				Reclaimed water	0.282 (3)	0.086 (4)
	Detoxification		0.308 (2)	Air quality	0.472 (1)	0.064 (8)
				Water quality	0.290 (2)	0.039 (13)
				Solid waste	0.238 (3)	0.032 (14)
Productivity		0.278 (2)		Labor productivity	0.303 (1)	0.084 (5)
				Energy productivity	0.272 (2)	0.076 (6)
				Water productivity	0.217 (3)	0.060 (9)
				Material productivity	0.208 (4)	0.058 (11)
Social contribution		0.281 (3)		Social investment	0.350 (1)	0.098 (2)
				Safety (health)	0.251 (2)	0.070 (7)
				Green label / certification	0.187 (4)	0.053 (12)
				Customer / consumer	0.211 (3)	0.059 (10)

Indonesia

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.466 (1)	0.484 (1)	Raw material	0.329 (2)	0.074 (8)
				Renewable energy	0.398 (1)	0.090 (3)
				Reclaimed water	0.274 (3)	0.062 (10)
	Detoxification		0.516 (2)	Air quality	0.367 (2)	0.088 (4)
				Water quality	0.420 (1)	0.101 (1)
				Solid waste	0.213 (3)	0.051 (12)
Productivity		0.310 (2)		Labor productivity	0.251 (2)	0.078 (6)
				Energy productivity	0.296 (1)	0.092 (2)
				Water productivity	0.206 (4)	0.064 (9)
				Material productivity	0.248 (3)	0.077 (7)
Social contribution		0.224 (3)		Social investment	0.209 (3)	0.047 (13)
				Safety (health)	0.353 (1)	0.079 (5)
				Green label / certification	0.198 (4)	0.044 (14)
				Customer / consumer	0.240 (2)	0.054 (11)

ROK

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.439 (1)	0.381 (2)	Raw material	0.269 (2)	0.045 (10)
				Renewable energy	0.505 (1)	0.084 (6)
				Reclaimed water	0.226 (3)	0.038 (12)
	Detoxification		0.619 (1)	Air quality	0.448 (1)	0.122 (2)
				Water quality	0.339 (2)	0.092 (5)
				Solid waste	0.213 (3)	0.058 (9)
Productivity		0.333 (2)		Labor productivity	0.366 (1)	0.122 (1)
				Energy productivity	0.250 (3)	0.083 (7)
				Water productivity	0.097 (4)	0.032 (13)
				Material productivity	0.287 (2)	0.096 (3)
Social contribution		0.228 (3)		Social investment	0.185 (3)	0.042 (11)
				Safety (health)	0.409 (1)	0.094 (4)
				Green label / certification	0.100 (4)	0.023 (14)
				Customer / consumer	0.306 (2)	0.070 (8)

Philippines

First tier criteria		Weight (order)		Second tier criteria	Weight (order)	Final weight (order)
Environmental sustainability	Dematerialization	0.460 (1)	0.375 (2)	Raw material	0.259 (3)	0.043 (13)
				Renewable energy	0.470 (1)	0.078 (5)
				Reclaimed water	0.270 (2)	0.045 (12)
	Detoxification		0.625 (1)	Air quality	0.385 (2)	0.106 (3)
				Water quality	0.390 (1)	0.107 (2)
				Solid waste	0.225 (3)	0.062 (9)
Productivity		0.317 (2)		Labor productivity	0.183 (4)	0.058 (10)
				Energy productivity	0.384 (1)	0.122 (1)
				Water productivity	0.209 (3)	0.066 (7)
				Material productivity	0.224 (2)	0.071 (6)
Social contribution		0.243 (3)		Social investment	0.214 (3)	0.052 (11)
				Safety(health)	0.408 (1)	0.099 (4)
				Green label / certification	0.122 (4)	0.030 (14)
				Customer / consumer	0.256 (2)	0.062 (8)

ANNEX 4. RANK OF COMPANIES BY COUNTRY

ROC

Companies	Dematerialization	Detoxification	Productivity	Social contribution
CC1	0	2	0	0
CC2	0	2	0	1
CC3	0	0	3	2.132
CC4	0.969	0	0.043	3
CC5	3	2	0.493	2.464
CC6	0	0	0	2
CC7	0.2	2	0	1
CC8	0.08	2	1.006	2.008
CC9	0.77	0.003	0.667	3.053
CC10	0	2	0	1
CC11	0.128	0	0.011	2.799
CC12	0	2	0.001	2.204
CC13	0.462	3	0	1.002
CC14	0	2.015	0.017	1
CC15	0.85	2	0.002	2

ROC (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
CC1	0	0.307	0	0	0.307	10
CC2	0	0.307	0	0.033	0.34	9
CC3	0	0	0.142	0.117	0.259	11
CC4	0.069	0	0.002	0.149	0.22	13
CC5	0.237	0.307	0.033	0.129	0.706	1
CC6	0	0	0	0.112	0.112	15
CC7	0.019	0.307	0	0.033	0.359	7
CC8	0.006	0.307	0.067	0.112	0.492	3
CC9	0.056	0	0.044	0.149	0.249	12
CC10	0	0.307	0	0.079	0.386	6
CC11	0.009	0	0.001	0.141	0.151	14
CC12	0	0.307	0	0.119	0.426	5
CC13	0.036	0.37	0	0.033	0.439	4
CC14	0	0.308	0.001	0.033	0.342	8
CC15	0.08	0.307	0	0.112	0.499	2

India

Companies	Dematerialization	Detoxification	Productivity	Social contribution
IC1	0.328	0	2.106	3.226
IC2	0.237	0	0.58	2.091
IC3	0.32	0	0.654	2.524
IC4	0.908	0	0.005	2.623
IC5	0.351	0.243	0.031	1.286
IC6	0.291	0	0.081	2.546
IC7	0.187	1	0.003	2.918
IC8	0.425	1	0.01	2.827
IC9	0.406	1	0.019	2.42
IC10	0.402	2	0.02	2.442
IC11	0.369	1	0.018	2.624
IC12	0.741	2	0.005	1
IC13	0.086	1	0.022	1
IC14	0.145	1	0.364	2.422
IC15	0.847	1.002	0.008	2.286
IC16	1.438	2	0.008	2.867
IC17	0.37	1	0.029	1
IC18	0	2	0.228	1
IC19	0.013	0	1.007	3.106
IC20	1.381	1	0.29	2.528
IC21	1.119	1	0.091	3.143
IC22	0.008	2.002	0.241	2.308
IC23	1	2.085	0	2.286
IC24	0.296	1	1.004	2.731
IC25	0.351	1	0.625	1.004
IC26	1	2	0.001	2.143
IC27	0.437	1	0.003	3.042
IC28	0.449	1	0.039	0
IC29	0.999	2	0.001	2.145
IC30	0.994	1	0.416	2.355

India (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
IC1	0.028	0	0.127	0.231	0.386	3
IC2	0.02	0	0.035	0.121	0.176	26

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Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
IC3	0.028	0	0.039	0.162	0.229	22
IC4	0.088	0	0	0.171	0.259	17
IC5	0.034	0.008	0.002	0.074	0.118	29
IC6	0.025	0	0.005	0.17	0.2	23
IC7	0.022	0.039	0	0.194	0.255	19
IC8	0.047	0.039	0.001	0.185	0.272	14
IC9	0.045	0.064	0.002	0.158	0.269	16
IC10	0.04	0.103	0.001	0.154	0.298	11
IC11	0.038	0.039	0.001	0.165	0.243	20
IC12	0.064	0.103	0	0.07	0.237	21
IC13	0.007	0.039	0.002	0.07	0.118	28
IC14	0.013	0.064	0.023	0.158	0.258	18
IC15	0.073	0.064	0	0.145	0.282	13
IC16	0.15	0.103	0	0.176	0.429	1
IC17	0.032	0.032	0.002	0.07	0.136	27
IC18	0	0.103	0.017	0.07	0.19	24
IC19	0.001	0	0.085	0.212	0.298	11
IC20	0.128	0.064	0.022	0.169	0.383	4
IC21	0.101	0.064	0.006	0.236	0.407	2
IC22	0.001	0.104	0.019	0.147	0.271	15
IC23	0.129	0.106	0	0.145	0.38	5
IC24	0.027	0.064	0.076	0.182	0.349	6
IC25	0.03	0.039	0.05	0.071	0.19	24
IC26	0.086	0.103	0	0.137	0.326	8
IC27	0.045	0.064	0	0.206	0.315	10
IC28	0.045	0.039	0.003	0	0.087	30
IC29	0.086	0.103	0	0.137	0.326	8
IC30	0.086	0.064	0.025	0.152	0.327	7

Indonesia

Companies	Dematerialization	Detoxification	Productivity	Social contribution
EC1	0.071	2.932	3.167	2.046
EC2	0.597	0	0	3
EC3	3	2	2	2.046
EC4	0.571	0.001	0.549	2.864
EC5	0	2	0	2.455

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Companies	Dematerialization	Detoxification	Productivity	Social contribution
EC6	0.606	1.002	0	2.182
EC7	0.731	2.043	0	2.139
EC8	0.099	0	0	1

Indonesia (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
EC1	0.005	0.237	0.242	0.135	0.619	2
EC2	0.044	0	0	0.177	0.221	7
EC3	0.226	0.189	0.169	0.135	0.719	1
EC4	0.047	0	0.042	0.171	0.26	6
EC5	0	0.139	0	0.153	0.292	4
EC6	0.051	0.088	0	0.141	0.28	5
EC7	0.059	0.191	0	0.139	0.389	3
EC8	0.006	0	0	0.047	0.053	8

ROK

Companies	Dematerialization	Detoxification	Productivity	Social contribution
KC1	0.643	2.015	2.405	0.117
KC2	0.984	3	0.364	0
KC3	0.34	1.002	0.002	2.078
KC4	3	2.001	0.698	1.503
KC5	0	2	1	0.386
KC6	0	2.083	1.793	3
KC7	0	2	1.689	0

ROK (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
KC1	0.024	0.215	0.154	0.005	0.398	3
KC2	0.044	0.272	0.028	0	0.344	6
KC3	0.013	0.092	0	0.096	0.201	7
KC4	0.167	0.214	0.064	0.044	0.489	2
KC5	0	0.214	0.122	0.016	0.352	4
KC6	0	0.219	0.142	0.135	0.496	1
KC7	0	0.214	0.137	0	0.351	5

Philippines

Companies	Dematerialization	Detoxification	Productivity	Social contribution
PC1	1.107	2	1.176	4
PC2	0	2.004	0.671	1.002
PC3	0.414	2.027	0.031	1.25
PC4	0	2.036	0	1
PC5	0	2.237	1.202	0.25
PC6	0.015	1.777	0.003	1.25
PC7	1	2.096	0	1.25
PC8	0	2.01	0.001	1.25
PC9	0	3	0	1.25
PC10	1	2.036	2.015	1
PC11	0	2.385	2.202	0.25
PC12	0.171	2	0	0
PC13	0	2.005	0	0

Philippines (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
PC1	0.082	0.213	0.079	0.243	0.617	1
PC2	0	0.213	0.039	0.062	0.314	8
PC3	0.018	0.215	0.004	0.107	0.344	6
PC4	0	0.215	0	0.099	0.314	8
PC5	0	0.228	0.075	0.007	0.31	10
PC6	0.001	0.154	0	0.107	0.262	11
PC7	0.043	0.219	0	0.107	0.369	5
PC8	0	0.214	0	0.107	0.321	7
PC9	0	0.275	0	0.107	0.382	4
PC10	0.045	0.215	0.126	0.099	0.485	2
PC11	0	0.237	0.204	0.007	0.448	3
PC12	0.008	0.213	0	0	0.221	12
PC13	0	0.213	0	0	0.213	13

Thailand

Companies	Dematerialization	Detoxification	Productivity	Social contribution
TC1	1	2.2	2.482	3
TC2	0	1	0.46	0

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Companies	Dematerialization	Detoxification	Productivity	Social contribution
TC3	0	2	0.301	1
TC4	0.11	1.002	1.156	1.167
TC5	0	1.6	1.496	1
TC6	0.466	1.05	0.201	1.5
TC7	0	1	2.207	1.167
TC8	0	1.016	0.517	1.183
TC9	0	1.011	0.556	1.333
TC10	0	1.067	1.176	1.267
TC11	0.145	1.08	1.231	1.1
TC12	0	1.004	1.201	2.077
TC13	1	1	1.14	3.667
TC14	0.057	1	0.469	2.033
TC15	0.892	1	1.378	2
TC16	0	1	1.227	3

Thailand (transformed by SAW)

Companies	Dematerialization	Detoxification	Productivity	Social contribution	Sum	Rank
TC1	0.09	0.18	0.203	0.144	0.617	1
TC2	0	0.07	0.043	0	0.113	16
TC3	0	0.193	0.019	0.077	0.289	5
TC4	0.009	0.07	0.083	0.05	0.212	10
TC5	0	0.144	0.09	0.043	0.277	6
TC6	0.037	0.076	0.016	0.062	0.191	13
TC7	0	0.07	0.141	0.05	0.261	8
TC8	0	0.072	0.032	0.05	0.154	15
TC9	0	0.071	0.036	0.056	0.163	14
TC10	0	0.078	0.068	0.053	0.199	12
TC11	0.011	0.08	0.074	0.047	0.212	11
TC12	0	0.071	0.081	0.123	0.275	7
TC13	0.079	0.07	0.075	0.169	0.393	2
TC14	0.004	0.07	0.029	0.121	0.224	9
TC15	0.07	0.07	0.087	0.12	0.347	3
TC16	0	0.07	0.072	0.158	0.3	4

ANNEX 5. WEIGHTS AND ORDERS OF COMPANIES

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer
EC1	0	0.003	0.054	1	1	0	0	0	0	0.098	0.001	1	0.045	1
EC2	0.021	0	0	0	0	0	0	0	0	0	0	1	1	1
EC3	0.035	0.177	1	1	1	0	0	0	0	0	0	1	0.045	1
EC4	0.004	0.064	0.1	0	0	0	0	0	0	0	0	1	0.864	1
EC5	0	0	0	1	0	0	0	0	0	0	0	1	0.455	1
EC6	0	0.085	0.126	1	0	0	0	0	0	0	0	1	0.182	1
EC7	0.002	0.081	0.205	1	1	0	0	0	0	0	0.002	1	0.136	1
EC8	0	0	0.099	0	0	0	0	0	0	0	1	0	0	0
IC1	0	0.02	0.165	0	0	0	0	0	0.011	0.001	0.01	1	0.136	1
IC2	0	0.02	0.116	0	0	0	0	0	0.002	0	0.001	0	0.318	1
IC3	0	0.02	0.161	0	0	0	0	0	0.002	0	0.001	1	0.136	1
IC4	0.01	0.144	0.289	0	0	0	0	0	0	0	0.002	1	0.136	1
IC5	0.005	0	0.136	0	0	0.009	0	0	0	0	0	0	0.091	1
IC6	0	0.04	0.132	0	0	0	0	0	0	0	0.003	1	0.091	1
IC7	0.007	0.04	0	0	1	0	0	0	0	0	0.004	1	0.182	1
IC8	0.011	0.06	0.071	0	1	0	0	0	0	0	0.003	1	0.182	1
IC9	0.011	0.005	0.096	1	0	0	0	0	0	0	0.002	1	0.091	1
IC10	0.006	0.02	0.139	1	1	0	0	0	0	0	0	1	0.136	1
IC11	0.007	0.09	0.07	0	1	0	0	0	0	0	0.001	1	0.182	1
IC12	0	0	0.4	1	1	0	0	0	0	0	0	1	0	0
IC13	0	0	0.047	0	1	0	0	0	0	0	0	1	0	0
IC14	0.001	0.04	0.049	1	0	0	0	0	0	0	0.002	1	0.091	1
IC15	0.001	0	0.45	1	0	0	0	0	0	0	0	1	0.091	1
IC16	0.027	0.385	0.243	1	1	0	0	0	0	0	0	1	0.273	1
IC17	0	0	0.2	0	0	0.035	0	0	0	0	0	1	0	0
IC18	0	0	0	1	1	0	0	0	0	0	0	1	0	0
IC19	0	0.008	0.002	0	0	0	0.003	0	0	0	0.006	1	0.182	1

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer
IC20	0.005	0.9	0.114	1	0	0	0	0	0	0	0.003	1	0.091	1
IC21	0.005	0.05	0.52	1	0	0	0	0	0	0	0.012	1	0.045	1
IC22	0	0	0.004	1	1	0	0.001	0	0	0	0	1	0.091	1
IC23	0.048	0	0	1	1	0.003	0	0	0	0	0	1	0.091	1
IC24	0.002	0.04	0.114	1	0	0	0	0	0	0	0.004	1	0.136	1
IC25	0	0	0.19	0	1	0	0.001	0	0	0	0	1	0	0
IC26	0	0	0.54	1	1	0	0	0	0	0	0	1	0.045	1
IC27	0.009	0.03	0.121	1	0	0	0	0	0	0	0.006	1	0.182	1
IC28	0.007	0	0.166	0	1	0	0	0	0	0	0	0	0	0
IC29	0	0	0.539	1	1	0	0	0	0	0	0	1	0.045	1
IC30	0	0.04	0.513	1	0	0	0	0	0.001	0	0.001	1	0.091	1
PC1	0	0.4	0	1	1	0	0	0	0	0	0.076	1	0.182	1
PC2	0	0	0	1	1	0	0	0	0	0	0	0	0	1
PC3	0	0	0.002	1	1	0	0	0	0	0	0	1	0.045	0
PC4	0	0	0	1	1	0	0	0	0	0	0	1	0	0
PC5	0	0	0	1	1	0	0	0	0	0	0	0	0.045	0
PC6	0	0	0	1	0	0	0	0	0	0	0	1	0.045	0
PC7	1	0	0	1	1	0	0	0	0	0	0	1	0.045	0
PC8	0	0	0	1	1	0	0	0	0	0	0	1	0.045	0
PC9	0	0	0	1	1	0	0	0	0	0	0	1	0.045	0
PC10	0	0	0.004	1	1	0	0	0	0	0	0	1	0	0
PC11	0	0	0	1	1	0	0	0.016	0	0	0	0	0.045	0
PC12	0	0	0.001	1	1	0	0	0	0	0	0	0	0	0
PC13	0	0	0	1	1	0	0	0	0	0	0	0	0	0
KC1	0	0	0.154	0	1	0	0	1	0.216	0	0.004	0	0	0
KC2	0.007	0	0	1	1	0	0	0.231	0.015	0	0	0	0	0
KC3	0	0	0.081	1	1	0	0	0	0	0	0.003	0	0.045	1

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer
KC4	0.007	0.139	0.239	1	1	0	0	0	0.011	0	0.016	0	0.045	0
KC5	0	0	0	1	1	0	0	0	0	0	0.013	0	0	0
KC6	0	0	0	1	1	0	0.045	0.41	0.082	0	0.033	0	0.045	1
KC7	0	0	0	1	1	0	0	0.872	0.047	0	0	0	0	0
TC1	0	0	0.047	1	1	0	0	0.025	0	0	0	1	0.045	1
TC2	0	0	0	1	0	0	0	0.008	0	0	0	0	0	0
TC3	0	0	0	1	0	0.001	0	0	0	0	0	1	0	0
TC4	0	0.097	0	1	0	0	0	0	0	0	0	0	0	1
TC5	0	0	0	1	0	0.001	0	0	0	0	0	0	0	1
TC6	0	0.412	0	1	0	0	0	0.001	0	0	0	0	0	1
TC7	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TC8	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TC9	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TC10	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TC11	0	0.128	0	1	0	0	0	0	0	0	0	0	0	1
TC12	0	0	0	1	0	0	0	0	0	0	0	1	0	1
TC13	0	0.884	0	1	0	0	0	0	0	0	0	1	0.045	1
TC14	0	0.05	0	1	0	0	0	0	0	0	0	1	0	1
TC15	0	0.789	0	1	0	0	0	0	0	0	0	1	0	1
TC16	0	0	0	1	0	0	0	0	0	0	0	1	0	1
CC1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
CC2	0	0	0	1	1	0	0	0	0	0	0	0	0	1
CC3	0	0	0	0	0	0	1	0	1	1	0	1	0	1
CC4	0.023	0	0.287	0	0	0	0.008	0	0.001	0.034	0.003	1	0	1
CC5	0.048	1	0.6	1	1	0	0.005	0.45	0	0	0.001	1	0.045	1
CC6	0	0	0	0	0	0	0	0	0	0	0	1	0	1
CC7	0	0.2	0	1	1	0	0	0	0	0	0	0	0	1

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer
CC8	0	0.03	0.03	1	1	0	0	0.923	0.005	0.001	0	1	0	1
CC9	0.019	0.02	0.21	0	0	0.003	0	0.615	0	0	0	1	0.277	1
CC10	0	0	0	1	1	0	0	0	0	0	0	1	0	0
CC11	0	0	0.075	0	0	0	0.009	0	0.001	0.001	0.003	1	0	1
CC12	0	0	0	1	1	0	0.001	0	0	0	0	1	0.045	1
CC13	0.019	0.04	0.013	1	1	1	0	0	0	0	0	0	0	1
CC14	0	0	0	1	1	0.015	0	0.015	0	0	0	0	0	1
CC15	0	0.85	0	1	1	0	0	0	0	0	0	1	0	1

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer	Sum	Rank
EC1	0	0	0.004	0.133	0.111	0	0	0	0	0.005	0	0.081	0.002	0.041	0.376	12
EC2	0.002	0	0	0	0	0	0	0	0	0	0	0.081	0.037	0.041	0.161	75
EC3	0.003	0.017	0.07	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0.041	0.457	2
EC4	0	0.006	0.007	0	0	0	0	0	0	0	0	0.081	0.032	0.041	0.168	73
EC5	0	0	0	0.133	0	0	0	0	0	0	0	0.081	0.017	0.041	0.272	43
EC6	0	0.008	0.009	0.133	0	0	0	0	0	0	0	0.081	0.007	0.041	0.279	40
EC7	0	0.008	0.014	0.133	0.111	0	0	0	0	0	0	0.081	0.005	0.041	0.393	10
EC8	0	0	0.007	0	0	0	0	0	0	0	0.045	0	0	0	0.052	89
IC1	0	0.002	0.012	0	0	0	0	0	0.001	0	0	0.081	0.005	0.041	0.142	78
IC2	0	0.002	0.008	0	0	0	0	0	0	0	0	0	0.012	0.041	0.063	87
IC3	0	0.002	0.011	0	0	0	0	0	0	0	0	0.081	0.005	0.041	0.14	79
IC4	0.001	0.014	0.02	0	0	0	0	0	0	0	0	0.081	0.005	0.041	0.162	74
IC5	0	0	0.01	0	0	0.001	0	0	0	0	0	0	0.003	0.041	0.055	88
IC6	0	0.004	0.009	0	0	0	0	0	0	0	0	0.081	0.003	0.041	0.139	80
IC7	0.001	0.004	0	0	0.111	0	0	0	0	0	0	0.081	0.007	0.041	0.244	56
IC8	0.001	0.006	0.005	0	0.111	0	0	0	0	0	0	0.081	0.007	0.041	0.251	52

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer	Sum	Rank
IC9	0.001	0	0.007	0.133	0	0	0	0	0	0	0	0.081	0.003	0.041	0.267	45
IC10	0	0.002	0.01	0.133	0.111	0	0	0	0	0	0	0.081	0.005	0.041	0.383	11
IC11	0.001	0.009	0.005	0	0.111	0	0	0	0	0	0	0.081	0.007	0.041	0.253	51
IC12	0	0	0.028	0.133	0.111	0	0	0	0	0	0	0.081	0	0	0.352	18
IC13	0	0	0.003	0	0.111	0	0	0	0	0	0	0.081	0	0	0.195	65
IC14	0	0.004	0.003	0.133	0	0	0	0	0	0	0	0.081	0.003	0.041	0.266	46
IC15	0	0	0.031	0.133	0	0	0	0	0	0	0	0.081	0.003	0.041	0.29	36
IC16	0.002	0.036	0.017	0.133	0.111	0	0	0	0	0	0	0.081	0.01	0.041	0.431	5
IC17	0	0	0.014	0	0	0.002	0	0	0	0	0	0.081	0	0	0.097	86
IC18	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0	0	0.324	27
IC19	0	0.001	0	0	0	0	0	0	0	0	0	0.081	0.007	0.041	0.13	82
IC20	0	0.085	0.01	0.133	0	0	0	0	0	0	0	0.081	0.003	0.041	0.354	17
IC21	0	0.085	0.036	0.133	0	0	0	0	0	0	0.001	0.081	0.002	0.041	0.299	33
IC22	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.003	0.041	0.369	15
IC23	0.004	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.003	0.041	0.373	13
IC24	0	0.004	0.008	0.133	0	0	0	0	0	0	0	0.081	0.005	0.041	0.272	43
IC25	0	0	0.013	0	0.111	0	0	0	0	0	0	0.081	0	0	0.205	63
IC26	0	0	0.038	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0.041	0.405	8
IC27	0.001	0.003	0.008	0.133	0	0	0	0	0	0	0	0.081	0.007	0.041	0.274	42
IC28	0.001	0	0.012	0	0.111	0	0	0	0	0	0	0	0	0	0.123	84
IC29	0	0	0.038	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0.041	0.405	8
IC30	0	0.004	0.036	0.133	0	0	0	0	0	0	0	0.081	0.003	0.041	0.298	34
PC1	0	0.038	0	0.133	0.111	0	0	0	0	0	0.003	0.081	0.007	0.041	0.414	6
PC2	0	0	0	0.133	0.111	0	0	0	0	0	0	0	0	0.041	0.285	38
PC3	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0	0.326	23
PC4	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0	0	0.324	27
PC5	0	0	0	0.133	0.111	0	0	0	0	0	0	0	0.002	0	0.245	55

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer	Sum	Rank
PC6	0	0	0	0.133	0	0	0	0	0	0	0	0.081	0.002	0	0.216	60
PC7	0.081	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0	0.407	7
PC8	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0	0.326	23
PC9	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0	0.326	23
PC10	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0	0	0.325	26
PC11	0	0	0	0.133	0.111	0	0	0.001	0	0	0	0	0.002	0	0.247	53
PC12	0	0	0	0.133	0.111	0	0	0	0	0	0	0	0	0	0.244	56
PC13	0	0	0	0.133	0.111	0	0	0	0	0	0	0	0	0	0.244	56
KC1	0	0	0.011	0	0.111	0	0	0.077	0.012	0	0	0	0	0	0.344	20
KC2	0.001	0	0	0.133	0.111	0	0	0.018	0.001	0	0	0	0	0	0.263	47
KC3	0	0	0.006	0.133	0.111	0	0	0	0	0	0	0	0.002	0.041	0.159	76
KC4	0.001	0.013	0.017	0.133	0.111	0	0	0	0.001	0	0.001	0	0.002	0	0.277	41
KC5	0	0	0	0.133	0.111	0	0.003	0	0	0	0.001	0	0	0	0.247	53
KC6	0	0	0	0.133	0.111	0	0	0.032	0.004	0	0.001	0	0.002	0.041	0.324	27
KC7	0	0	0	0.133	0.111	0	0	0.067	0.003	0	0	0	0	0	0.314	31
TC1	0	0	0.003	0.133	0.111	0	0	0.002	0	0	0	0.081	0.002	0.041	0.373	13
TC2	0	0	0	0.133	0	0	0	0.001	0	0	0	0	0	0	0.134	81
TC3	0	0	0	0.133	0	0	0	0	0	0	0	0.081	0	0	0.214	61
TC4	0	0.009	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.174	72
TC5	0	0	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.174	67
TC6	0	0.039	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.214	62
TC7	0	0	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.174	67
TC8	0	0	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.174	67
TC9	0	0	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.174	67
TC10	0	0	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.174	67
TC11	0	0.012	0	0.133	0	0	0	0	0	0	0	0	0	0.041	0.187	66
TC12	0	0	0	0.133	0	0	0	0	0	0	0	0.081	0	0.041	0.255	49

Companies	Raw material	Renewable energy	Reclaimed water	Air quality	Water quality	Solid waste	Labor productivity	Energy productivity	Water productivity	Material productivity	Social investment	Safety (health)	Green label and certification	Customer and consumer	Sum	Rank
TC13	0	0.084	0	0.133	0	0	0	0	0	0	0	0.081	0.002	0.041	0.341	21
TC14	0	0.005	0	0.133	0	0	0	0	0	0	0	0.081	0	0.041	0.26	48
TC15	0	0.075	0	0.133	0	0	0	0	0	0	0	0.081	0	0.041	0.33	22
TC16	0	0	0	0.133	0	0	0	0	0	0	0	0.081	0	0.041	0.255	49
CC1	0	0	0	0.133	0.111	0	0	0	0	0	0	0	0	0	0.244	56
CC2	0	0	0	0.133	0.111	0	0	0	0	0	0	0	0	0.041	0.285	38
CC3	0	0	0	0	0	0	0.066	0	0.055	0.048	0	0.081	0	0.041	0.291	35
CC4	0.002	0	0.02	0	0	0	0.001	0	0	0.002	0	0.081	0	0.041	0.146	77
CC5	0.004	0.095	0.042	0.133	0.111	0	0	0.035	0	0	0	0.081	0.002	0.041	0.543	1
CC6	0	0	0	0	0	0	0	0	0	0	0	0.081	0	0.041	0.122	85
CC7	0	0.019	0	0.133	0.111	0	0	0	0	0	0	0	0	0.041	0.304	32
CC8	0	0.003	0.002	0.133	0.111	0	0	0.071	0	0	0	0.081	0	0.041	0.442	4
CC9	0.002	0.002	0.015	0	0	0	0	0.048	0	0	0	0.081	0.008	0.041	0.196	64
CC10	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0	0	0.324	27
CC11	0	0	0.005	0	0	0	0.001	0	0	0	0	0.081	0	0.041	0.128	83
CC12	0	0	0	0.133	0.111	0	0	0	0	0	0	0.081	0.002	0.041	0.367	16
CC13	0.002	0.004	0.001	0.133	0.111	0.061	0	0	0	0	0	0	0	0.041	0.352	18
CC14	0	0	0	0.133	0.111	0.001	0	0.001	0	0	0	0	0	0.041	0.287	37
CC15	0	0.08	0	0.133	0.111	0	0	0	0	0	0	0.081	0	0.041	0.446	3


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