

# Enhancing ESG Insights Using Machine Learning: A Case Study of Top Performing Banks in Indonesia

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## ABSTRACT

This research related to the discover ESG practices by Top Performing Banks in Indonesia based on their Return on Asset (ROA) and Net Interest Margin (NIM). Due to the shifting the interest of the investor and the world condition. Recently, investors have shown a growing inclination to incorporate ESG (Environmental, Social, and Governance) considerations into their decision-making processes. This trend is driven by a heightened awareness of environmental risks, particularly those linked to sustainability. In response to climate change, there is also a growing public interest in adopting more sustainable practices. Due to the broad and sometimes ambiguous definition of ESG, identifying the specific practices that should be implemented by banks remains challenging. Research on frameworks to guide these actions is still limited. For instance, explores the role of knowledge management in facilitating the integration of ESG factors. This research aims to create an ESG knowledge discovery framework with Natural Language Process (NLP) based on DBSCAN results of several companies which have good financial performance such as Return on Asset (ROA) and Net Interest Margin (NIM). The result will be analyzed by NLP, especially TF-IDF (Term Frequency - Inverse Document Frequency) and visualized by Word Cloud. The priority of Top Performing Bank in Indonesia related to the environment indicator conduct the activity which focus on carbon, green, and water. For social indicator, the main focus are employee, training, and financial. Lastly, for governance indicator, they are most prominent activity to the security, data, and policy. Overall, leading banks in Indonesia tend to prioritize environmental aspects in their operations. Companies with strong environmental initiatives have been shown to positively impact their earnings and financial performance.



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## I. INTRODUCTION

Nowadays, 106 banks increasingly mushrooming in Indonesia and already registered by Indonesia Financial Services Authority (OJK). Unfortunately, only 19 banks which have ESG (Environmental, Social, and Governance) score based on Morningstar Sustainability. It indicates that many banks in Indonesia that has lack of interest to ESG scores, especially to ESG. Nevertheless, the investor is took this into account.

The investor escalates their tendency to consider the ESG issue in the process of decision-making recently [1]. This phenomenon is a consequence of increasing awareness on risks related to the environment, especially sustainability [2], [3]. Nowadays, most people are interested in being more and more sustainable [4] due to climate change which creates disasters such as drought [5], flood, increasing sea level rise [6], [7] and land subsidence [8] in Indonesia. Therefore, the investor intends to their investment concern about that field. Besides that, major academic literature indicates that the relationship between ESG and corporate financial

performance is positive [9], [10], [111]. This financial risk can emerge due to the fraudulence or accidents which related to environmental, social, and governance aspects [12]. The company should not only give attention to ESG but also the cost performance or in broader term is financial performance [13].

Unfortunately, with the broad definition of ESG, it is difficult to define how to determine the practice that should be implemented in the bank. There is limited research related to the framework to determine those actions. Saviano, *et al.* [14] conduct research related to how knowledge management's role in the integration of ESG factors. Kumari and Sharan [15] discuss the scope of sustainability practices in banks assisted by the Information and Communication Technology (ICT) support knowledge management platform. Raghupathi, *et al.* [16] extract insight into sustainability knowledge with the combination of text analytic approaches based on shareholder resolution.

This research aims to create an ESG knowledge discovery framework. It is useful to discover ESG lessons learned from the bank which has good financial performance as the knowledge for bank in Indonesia to enhance their sustainability practices and improve overall performance. The financial performance should be also considered due to [13] argues that a company should not give single attention to ESG but also the cost performance or in broader terms financial performance. One of the famous financial performances is ROA (Return on Asset) [17]. With ROA, it will be discovered how profitable a firm's assets are in generating margin [18]. There is another financial indicator which able to be a significant supplement of ROA is the overall profitability which is Net of Interest Margin (NIM) [19]. NIM is included in one essential aspect, it is able to encapsulate the financial intermediation role, especially in banks [20]. The selected banks with good ROA and NIM as the result of the Unsupervised Clustering which is Density-Based Clustering Spatial of Application with Noise (DBSCAN) process. The selection of clustering method is due to the ability of DBSCAN. DBSCAN enables to be highly flexible across various datasets, effectively detecting clusters of any shape [21]. Then, this research will combine the DBSCAN and NLP, especially TD-IDF. It is difficult to find the integration of DBSCAN and NLP. It is used to integrate with Sequential Mining Optimization (SMO) [22] K-Means [23], and Density Peak Algorithm [24]. The insight from sustainability reports of selected banks are extracted using Natural Language Processing (NLP).

The framework enables Indonesian banks to adopt effective ESG strategies. The outcome of the framework will be the guideline for other banks on what initiative from each ESG should be implemented to attract customers and maintain the viability bank due to its sustainability. This approach supports data-driven decision-making and contributes to long-term resilience in the banking sector.

## II. LITERATURE REVIEW

### A. ESG (Environmental, Social, and Governance)

Sustainability become important increasingly by time. This is in line with the ESG (Environmental, Social, and Governance) aspects has roles to be a competitive strategy recently in order to achieve investor's interest [25]. It demonstrates that three aspects such as environmental, social, and governance have main role in sustainability existence. Therefore, the problem related to the three aspects will influence the sustainability of a firm such as [26]:

- 1) *Environmental*: The common problems are pollution, waste generation, climate change, water scarcity, biodiversity, energy consumption, and deforestation
- 2) *Social*: The general issue is employee engagement, child- and forced labor, gender and diversity policies, stakeholder relations, human rights, community engagement, health and safety, customer satisfaction
- 3) *Governance*: The quality of the transparency, political contribution, disclosure, audit, lobbying, board and management as well as executive and board compensations are some examples of content.

### C. Return on Asset

ROA delineates how a company's assets are worthwhile in leading to earning revenue and how effective the company operates [18]. Therefore the formula of ROA as below,

$$ROA = \frac{EBIT}{Total\ assets}$$

Total asset is comprised of shareholders' equity, long term debt, and other liabilities. Whereas, EBIT (earning before interest and taxes) is company's revenue including a portion for shareholders, debt holders, and the taxman [27]

### D. DBSCAN (Density Based Clustering Spatial of Application with Noise)

Clustering is the process of classify some data items into group based on resemblance and different group according to discrepancy. Clustering is unsupervised learning [28], means that a set of of a assemblage of statistical technique addressed to problem's characteristic which a set of features  $X_1, X_2, \dots, X_p$  measured on  $n$  observations [29]. An alternating algorithm from clustering is DBSCAN. DBSCAN is classical density-based clustering algorithm and acknowledged straightforward and efficient method [30]. This algorithm is begun with the unexplored arbitrary point of data. Then the points in  $\epsilon$  distance are positioned from the neighboring point  $p$ . The aim is the total number of data points enclosed by the neighborhood radius of  $N_\epsilon(p)$  are achieved based on the formula (1):

$$N_\epsilon(p) = \{q \in D | dist(p, q) \leq \epsilon\}$$

$N_\epsilon(p)$  and  $MinPts$  are compared in order to prescribing the state of data points in certain way that if  $MinPts > N_\epsilon(p)$ , then  $p$  will be recognized as noise. This technique will be applied for all the points that lie within the neighborhood of  $p$  until all cluster points are identified and all the points are labeled. Through this algorithm, Euclidean distance is used for compute distance between each points.

$$dist(p, q) = (q_t - p_t)^2 + (q_h - p_h)^2 + (q_h - p_h)^2$$

#### E. Net Interest Margin

Net interest margin means the difference between interest revenue on bank assets with interest expense on bank liabilities as the percentage of bank asset or can be represented as a function of internal (bank-specific) and external (industry-related, macroeconomic, and regulatory) [31]. Moreover, the formula of Net interest Margin as below [32],

$$Net\ Interest\ Margin = \frac{Net\ Interest\ Income}{Earning\ Assets}$$

$$Net\ Interest\ Income = Interest\ Income - Interest\ Expense$$

#### F. NLP (Natural Language Processing)

NLP or computational linguistics is a branch of artificial intelligence with the purpose to understand, acknowledge, and produce human language content[33]. Therefore, the main focus of NLP is language and text [34]. NLP's role as the bridge the divide between human interaction and computer comprehension [35]. The result of NLP is able to be visualized by Word Cloud. A word cloud is exist to demonstrate single words, and how the importance of each word is represented by size and color. From the visualization, the quick decision can easily create be related to the most dominant term. The size of a word in visualization is based on each word's frequency. The larger the word, the more common the word in the data [36].

#### G. Term Frequency - Inverse Document Frequency (TF-IDF)

TF-IDF consist of TF and IDF. TF (Word frequency) is the frequency of word discovered in document, while IDF (inverse document frequency) represent how useful those word to distinguish text categories in classification [37]. The frequency information is computed to measure the important of the word [38]. TF-IDF has focuses on the value of key behaviors, with divide two categories in document such as keywords and non-keywords [39].

### III. METHOD

All of twenty-one Indonesia financial banks' ROA and NIM on 2024 where the data is published in Wall Street Journal is collected. Those financial banks' ROA and NIM data will be clustered by DBSCAN approach. Then, one of the clusters will be selected due to the highest ROA and NIM.

The sustainability report of those banks are analyzed. This report related to what the company has been done in 2023 with aim to maintain sustainability. Each of ESG practices by financial bank in selected cluster will be analyzed by TD-IDF and visualized by Word Cloud. The results indicate the most priority of ESG practices of selected Bank and are able to be the reference of other banks. In this research, the priority in each aspect will be mentioned sequentially based on the level of priority.

### IV. RESULT AND DISCUSSION

#### A. Validation

From figure 1 with assistance of elbow method, it is known that the epsilon 0.06 will be used. Also in this research the minPts is 2 because the data available is few. According to the epsilon, the silhouette coefficient is 0.85. Therefore, the data point is said to be properly clustered and well-separated from nearby clusters if the silhouette coefficient is near +1 [40],[41].

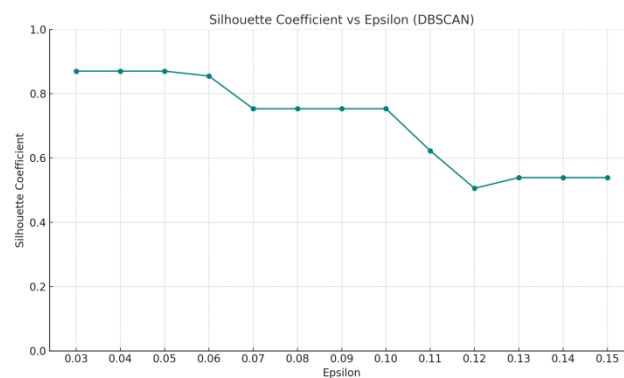


Figure 1. Silhouette Coefficient vs Epsilon

#### B. Clustering

From the clustering there are several outliers and 3 clusters. The data is available below, but not included the outlier. From the table, it displays that Bank A and Bank B are clustered in Cluster 1. While in Cluster 2, there are Bank C, Bank D, Bank E, and Bank F. And in cluster 3, there are Bank G, Bank H, and Bank I. In order to select the best cluster, it will be more straightforward to use the visualization of clustering.

TABLE I  
RESULT OF FINANCIAL BANK CLUSTERING

No.	Cluster	Name of Bank	NIM	ROA
1.	1	Bank A	0.0514	0.0507
2.	1	Bank B	0.0525	0.0448
3.	2	Bank C	0.0349	0.0088
4.	2	Bank D	0.0375	0.0083
5.	2	Bank E	0.0352	0.0089
6.	2	Bank F	0.0351	0.0131
7.	3	Bank G	0.0494	0.0117
8.	3	Bank H	0.0586	0.0136
9.	3	Bank I	0.0557	0.0142

In Figure 2, those points are colored and grouped into clusters. The green, orange, and blue points represent cluster 1, cluster 2, and cluster 3 respectively. While the black points mean not belonging to any cluster or it is called outlier. Green point is selected due to its highest position. The highest position indicates high ROA and NIM. Based on the figure 1, the highest position is cluster 1 which consists of Bank A and Bank B. Due to those factors, the sustainability report of Bank A and Bank B will be analyzed by NLP.

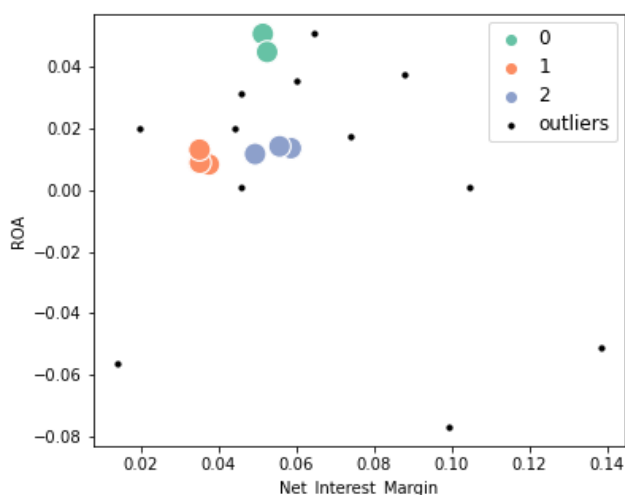


Figure 2. Visualization of Financial Bank Clustering

### C. NLP

The sustainability report of each bank is summarized. The summary is the short discussion related to Bank's practice in term of the ESG aspect in one year. Then, the summary is broken down based on the three aspects which are Environmental, Social, and Governance. Therefore, with its own topic, there are three summaries. It is expected the differentiate summary will create clear view of each aspects practices for other banks.

### D. TF-IDF

The result of TF-IDF is gained based on the calculation. In this discussion, the main or dominant topic in their report. It is separated based on the aspects, which are Environmental, Social, and Governance.

1) *Environmental*: The summary related to the environmental is processed by NLP, especially by TF-IDF and Word Cloud. It is shown in Table II and Figure 3, that the highest score of TF-IDF are carbon, green, and water. It is also illustrated in the Figure 4, the visualization highlights key terms. It is known that the selected banks' most initiatives pertaining to carbon, green, and water then followed operational, and emission. Therefore, the main discussion of environmental aspect are carbon, green, and water. Overall bank initiatives as in the form of environmental concerns and as the behavior for encountering the climate change.

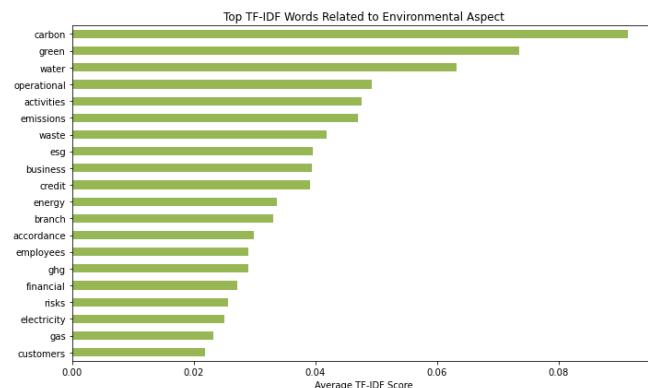


Figure 3. Top TF-IDF Related to Environmental Aspect

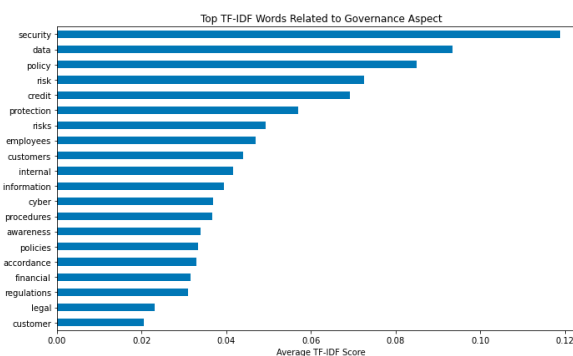
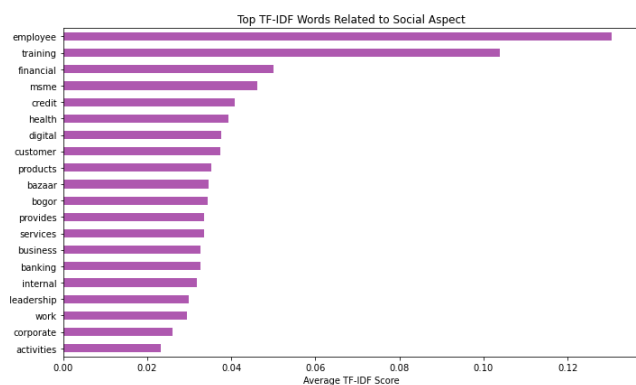


Figure 4. Word Cloud of Environmental Initiatives

TABLE II  
TF-IDF SCORE OF ENVIRONMENTAL

No.	Term	TF	TF-IDF
1	carbon	0.13	0.09
2	green	0.12	0.07
3	water	0.09	0.06
4	activities	0.1	0.05
5	emissions	0.09	0.05
6	operational	0.07	0.05
7	business	0.06	0.04
8	waste	0.06	0.04
9	credit	0.05	0.04
10	financial	0.04	0.03

2) *Environmental*: From the result, it is discovered that the social practices of Banks in selected cluster is most focus on employee, training, financial exposed in Figure 5 and Table III. It is displayed in the Figure 6, the visualization displays that the social practices of Banks in selected cluster is most focus on employee, training, financial and then followed by MSME (Micro, Small, and Medium Enterprises), credit, and health. The target social practice is both for internal and external such as employee and customer. Based to the priority, they are more concern on their internal, because there is also training for the employee. They realize that for achieve the high performance, they need to enhance the ability of their internal.

TABLE III  
TF-IDF SCORE OF SOCIAL

No.	Term	TF	TF-IDF
1	employee	0.23	0.13
2	training	0.16	0.1
3	financial	0.09	0.05
4	msme	0.06	0.05
5	credit	0.05	0.04
6	customer	0.07	0.04
7	products	0.05	0.04
8	health	0.04	0.04
9	digital	0.05	0.04
10	bazaar	0.04	0.03

3) *Governance*: Finally, summary's focused on the governance practice and it is examined by TF-IDF and it is displayed in Figure 7 and Table IV. Also it is supported by the visualization in Figure 8, represented that selected bank's most prominent governance activity on security, data and policy. Then followed by risk and credit. The governance aspect emphasizes on security and also including its comprehensive approach. In terms of exhibit their loyalty and ensuring customer's trust, they need to secure the information data which its confidentiality is important for their customers and their own self.

#### D. Discussion

The selected bank's sustainability reports was processed and only ESG-related action statements which collected. Multiple statements with the same meaning are eliminated, retaining only a single representative statement. All the collected statements will be categorized based on their relevance to the each of ESG Aspects.

as carbon trading, procuring carbon units, and purchasing Verified Carbon Units (VCU). Their support is visible due to their other movement such assist and direct customer with carbon-intensive business activity, associate with the organization which concern to the carbon. It is known that carbon which to be discuss above is specifically to the emission. From the sustainability report, the disclose both banks initiatives related to carbon emission with accordance with GRI 305 Standards: Emission which in detail in Table V.

TABLE V  
GRI STANDARD - CARBON OVERVIEW

No.	GRI Standard	Indicator	Disclosure	Compliance	
				Bank A	Bank B
1	GRI 305 : Emission	GRI 305-1	Direct GHG Emissions	Yes	Yes
2		GRI 305-2	Energy indirect GHG Emissions	Yes	Yes
3		GRI 305-3	Other Indirect GHG Emissions	Yes	Yes
4		GRI 305-4	GHG emission intensity	Yes	Yes
5		GRI 305-5	Reduction of GHG emissions	No	Yes

Bank also direct their practice to the green activities. In the term of their business, they begin the Indonesian Green Taxonomy (GT) Pilot Project. Based on their financial activity, they issue green investment and green loans, especially for the EV Battery component industry and finance business activity with the sustainability principle. Also, they provide guidelines to calculate Greenhouse Gas (GHG) Emissions as the result of financing and investment activities based on Greenhouse Gas Protocol which as the representation of their engagement with GHG Management. Related to their relationship with customer, they implement a data analytic green processing in order to differentiate them whether the customer is green or non-green. In order to represent their support, they promote green innovation and assist greening their residential areas through providing infrastructure support for urban farming activities. Not only focus with external infrastructure, but also their internal such design and operates green building accordance with Green Building Council Indonesia (GBCI) standards which lead them to the ownership of Green Building certificate. This overall green initiatives related to efficient of energy and waste. Therefore, sustainability report of Both Banks are align with GRI 302: Energy 2016, which the detail is displayed in Table VI.

2) *Social Aspect:* In the social aspects, banks manage intense attention to their employee. The employee including

TABLE VI  
GRI STANDARD - GREEN OVERVIEW

No	GRI Standard	Indicator	Disclosure	Compliance	
				Bank A	Bank B
1	GRI 302 : Energy 2016	GRI 302-1	Energy consumption within the organizations	Yes	Yes
2		GRI 302-2	Energy Consumption Outside the Organization	No	Yes
3		GRI 302-3	Energy Intensity	Yes	Yes
4		GRI 302-4	Reduction of Energy Consumption	Yes	Yes

the top, middle, and low-level Management. The bank provides training, sharing session, socializing, strategy, program and certification with the purpose of performance enhancement related to the leadership, financial, digital, transaction, and professionalism. Their employee's performance will be evaluated by annual performance evaluation based on the achievement of Key Performance Indicator. Also, with good and high-performance culture the employee can gotten be promoted and appreciated through several events, awards, and championship. And they provide the forum to channel the employees' interest and talent. Performance is not only the banks focusing about, but also the engagement. They concern about it from the beginning. Their recruitment is complied with all legal standards and ethical norms. And in the its operational running. The Banks conduct the survey related to the employee's engagement which embodied in the Collective Labor Agreement (CLA) and the banks commits to accommodate the best place to work comfortably. In order to maintaining, the bank consider their grievances by providing its mechanism. Moreover, they are supplied by health facilities and communal homecoming for the employee and their family. Then, they respect the right of their employee such as leave entitlement. There are various leave entitlements such as maternity and paternity not only for female but also male. Also, the banks appreciate what employee already done through the retirement preparation program. Employee discussion in sustainability report is align with GRI 3: Material Topics, GRI 401: Employment 2016 and GRI 403: Occupational Health and Safety. The detail of those GRI standard is shown in Table VII

For the target of training, which conducted by the bank, is both internal and external for employee and public. In order to enhance the capabilities and performance of their employee, they conduct various training. For employee, there are various types the available training for the employees related to the standard, financial, digital.



TABLE VII  
GRI STANDARD - EMPLOYEE OVERVIEW

No	GRI Standard	Indicator	Disclosure	Compliance	
				Bank A	Bank B
1	GRI 3 : Material Topics 2021	GRI 3-3	Management of Material Topics	Yes	Yes
2	GRI 401: Employment 2016	GRI 401-1	New Employee Hires and Employee Turnover	Yes	Yes
3		GRI 401-2	Benefits provided to full time employees that are not provided to temporary or part-time employees	Yes	No
4		GRI 401-3	Parental Leave	Yes	No
5	GRI 403 : Occupational Health and Safety 2018	GRI 403-1	Occupational Health and Safety Management System	No	Yes
6		GRI 403-2	Hazard Identification, Risk Assessment, and Incident Investigation	No	Yes
7		GRI 403-3	Occupational Health Services	No	Yes
8		GRI 403-4	Worker Participation, Consultation, and Communication on Occupational Health And Safety	No	Yes
9		GRI 403-5	Worker Training on Occupational Health and Safety	No	Yes
10		GRI 403-6	Promotion of Worker Health	No	Yes
11		GRI 403-7	Prevention And Mitigation of Occupational Health And Safety Impacts Directly Linked by Business Relationships	No	Yes
12		GRI 403-8	Workers Covered by An	No	Yes

			Occupational Health and Safety Management System		
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transaction, policy, data security, climate, technical skill and soft skill. The selected bank also concerns with the public, especially MSME (Micro, Small, and Medium Enterprises). Many training conducted in order to build up their business performance. The training related to the digital payment, packaging, cooking class, creativity activity, product design etc. In the sustainability they put the many training was conducted for employee and MSME. This training activity report is align with GRI 3: Material Topics 2021 and GRI 404: Training and Education, its indicators are shown in Table VIII.

TABLE VIII  
GRI STANDARD - TRAINING OVERVIEW

No	GRI Standard	Indicator	Disclosure	Compliance	
				Bank A	Bank B
1	GRI 3 : Material Topics 2021	GRI 3-3	Management Of Material Topics	Yes	Yes
2	GRI 404 : Training and Education 2016	GRI 304-1	Average Hours of Training Per Year Per Employee	Yes	Yes
3		GRI 304-2	Programs For Upgrading Employee Skills and Transition Assistance Programs	Yes	Yes
4		GRI 304-3	Percentage Of Employees Receiving Regular Performance and Career Development Reviews	Yes	Yes

3) *Governance Aspect:* For governance aspects the major concern only on security. With the intention of maintain loyalty and trust from the customer, the banks conduct many things related to the security of information. Banks establish the information security strategy, regulation, and standards with aims to maintain confidentiality and integrity of customer's data. Prior determine that, the banks already identify data security risks. Not solely policy, but also there is real action maintain the security. The banks do multilayered and tools to their security system including the protection of applications, networks, data, endpoints, IT infrastructure, and system. This protection is continuously improved with latest,

credible, and best-in-class technology and source due to follow the cybersecurity advancement. The applied technology such as firewalls, anti-malware, antivirus, data encryption system, and application security devices.

The security incident is mitigated by international standards (certified ISO 27001) with international best practices and Cyber Team. Cyber Team is one division which concern to the security, other division such as IT Cyber Security, IT Internal Control, and Cyber Team. Not solely the Cyber Team but also all employees got security awareness certification on an annual basis. This certification is ensuring the understanding of the importance of information security policies and procedure, including protect customer data and information approach. Furthermore, the security of workplace equipment is concerned such as employee customer, restrict access to external email and specific internet website, deactivate USB ports on employee customer, utilizing Data Leak Prevention measures for unauthorized external email transmissions. Those two between security and data related to the customer privacy which are align with GRI 418: Customer Privacy, which the detail are displayed in Table IX.

TABLE IX  
GRI STANDARD - SECURITY AND DATA OVERVIEW

No.	GRI Standard	Indicator	Disclosure	Compliance	
				Bank A	Bank B
1	GRI 418 : Customer Privacy 2016	GRI 418-1	Substantiated Complaints Concerning Breaches of Customer Privacy and Losses of Customer Data	Yes	Yes

#### F. Overall Insight

Prihandini [42] already reveal ESG score of each aspect by Bank A and Bank B. It is known that both Bank A and Bank B have main focus on Environmental aspect. It is not surprisingly that both Banks have highest ROA and NIM. Environmental and societal obligations of firms have been found to positively influence their earnings and financial outcomes. Especially, with emission and waste reductions having a significant positive impact on both financial and operating performance [43],[44],[45].

#### V. CONCLUSION

The framework of enhanced ESG Practices Insight based on Top Bank is created with approach of DBSCAN clustering and NLP with Word Cloud visualized. There are 21 banks are processed due to their NIM and ROA. Based on DBSCAN clustering, there are 3 clusters and the rest are outliers. The first cluster contains Bank A and Bank B. The second cluster consists Bank C, Bank D, Bank E, and Bank F. The last cluster

encompasses Bank G, Bank H, and Bank I. From the visualization, it reveals that the best cluster is cluster 1 due to its position which indicates the selected bank has high ROA and NIM. The selected banks' sustainability report is processed by TD-IDF in order to find each ESG aspect initiatives. The priority of selected banks related to the environment conducts the activity which focus green and carbon. The selected banks direct their focus on the activity which concern to the environment or famously know as green. Also pay much attention to carbon as the main cause of climate change. From the social perspective, the selected bank majority highlights training and employee. Most of primary social activity is concern on the internal. The selected bank aware that in order to achieve high performance, they need to strengthen their internal. In addition, for governance practice, they have prominent activity which maintain the security of the information data. They need to secure the confidentiality of information data of customer and their own self. This topic already discussed in their Sustainability Report which are align with GRI Standard. Also, Both Bank have more interest to the environmental only.

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