American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402
© Global Society of Scientific Research and Researchers
http://asrjetsjournal.org/

A Comparative Study on the Relations among Sustainability Focused Indexes with REC, CO_2, and GDP

Birkan Durmuşoğlu[a], Ayşe Ayçim Selam[b]*, Seniye Ümit Oktay Fırat[c]

[a,b,c]*Marmara University, Göztepe Campus, Kadıköy, İstanbul, 34722, Turkey*

[a]*Email: birkandurmusoglu@gmail.com*

[b]*Email: aselam@marmara.edu.tr*

[c]*Email: suofirat@marmara.edu.tr*

Abstract

Sustainability has become one of the important concepts of countries due to global warming and climate change. In order to assess the sustainability and environmental performance of countries foundations publish sustainability focused indexes which help researchers and governments to position countries according to related indicators. At the same time, there are some variables which provide environmental and economic information; measured per country. The aim of this study is to investigate the relation between six selected sustainability focused indexes (CCPI, EPI, ETI, SSI-HW, SSI-EW, and SSI-ECW) and selected variables namely, REC, CO_2, and GDP. In this study, Spearman's rank correlation is used to identify the strength of an association between sustainability focused indexes and selected variables for 25 countries. It is seen that to REC has a monotonic correlation with ETI and EPI; CO_2 emissions has negative correlations with CCPI and SSI-EW as expected; and GDP has positive correlation with all five indexes except CCPI. The results of this study suggest that the increase on renewable energy consumption and the decrease on CO_2 emissions are the main factors for environmental performance which are mitigate climate change and global warming.

Keywords: Sustainability Indexes; CO_2 Emissions; Environmental Performance; Spearman Rank Correlation.

1. Introduction

The global warming and climate change has become an important subject for researchers and many studies have been made in recent years. Despite, carbon dioxide (CO_2) is accepted as the main reason of global warming, renewable energy sources are also accepted as the alternative solution to solve climate change [1].

---

* Corresponding author.

On the other hand, Gross Domestic Product (GDP) is considered a measure of economic growth and can be considered as another important factor that affects both CO_2 emissions and Renewable Energy Consumption (REC). These three variables have taken into account on many studies evaluating energy usage and emissions [2, 3, 4, 5, 6, and 7]. On the other hand, there are many indexes that help to understand the development of sustainability and environmental performance of countries. The aim of this study is to investigate relation between selected variables REC, CO_2 emissions, GDP, and sustainability focused indexes. The indexes are selected due to their related indicators and will also be helpful to evaluate which of the selected variables have an effect on sustainability and sustainable development. Recent indexes elected for this study are Climate Change Mitigation Performance (CCPI), Environmental Performance Index (EPI), Energy Trilemma Index (ETI) and Social Society Index (SSI) with 3 wellbeing dimensions (human, environmental, economic) taken into account separately. CO_2 emissions and REC in the recent years is used to eliminate 25 countries to be analyzed in this study. Spearman's rank correlation is a statistical technique to identify the strength of an association of two variables [8]. Scatter Plot Matrices are provided and the Spearman's rank correlation test with Critical Correlation Value (rho): 0.415 is applied for each variable and index.

In the second section a brief literature review is provided. Third section describes data used in this study. Fourth section investigates the detailed information on the selected indexes. Each variable is analyzed with Spearman's rank correlation method in section 5. Finally, section 6 discusses the results and concludes the study.

2. Literature Review

The impact of offshore wind energy to society's wellbeing in UK is analyzed and suggested that there is strong evidence that wind offshore wind industry has beneficial effect on sustainable development and it contributes to social, economic and environmental wellbeing in UK [9]. The potential contribution of renewables on living conditions in the poor area in Cameroon shows that the renewable energy can play crucial role to achieve sustainable and environmental development [10]. EPI of China between 2006 and 2011 is evaluated and indicated that some regions include Shanxi (at minimum) and Beijing (at maximum) showed a significant improvement on environmental performance [11]. Also, the study suggests that the government must focus on the development of sub-regions to improve air and water quality and sustainable resources.

The relationship between energy security index and renewable energy deployment in the European Union (EU) is analyzed finding that renewable energy deployment is a key factor to make energy more secure and it helps to reduce energy dependency [12]. Therefore, it can be concluded that renewable energy has an important role to create sustainable energy. The effects of energy consumption, CO_2 emission and economic development on sustainable growth is researched and concluded that developing countries has really poor performance on environmental sustainability because the development on economy is related to increase on CO_2 emissions [13]. Therefore, the study suggests that developed countries should create a fund for developing countries to achieve environmental reforms. The impact renewable energy and its institutions on economic growth and CO_2 emissions suggested that renewable energy deployment and institutions have a significant contribution to economic development and have an important role to reduce CO_2 emissions [7].

3. Data Description

The data is collected for variables, indexes and 25 selected countries. The variable REC is collected for year 2015 due to availability. However, CO_2 emissions, and GDP data are provided for recent year, 2016. The list of these variables and detailed information is provided in Table 1.

Table 1: List of Variables

Variable	Abbreviation	Source	Unit
Renewable Energy Consumption	REC	OECD	TPES
Carbon Dioxide Emission	CO_2	WorldBank	KTon
Economic Growth	GDP	WorldBank	US $

Evaluation of environmental performance is a vital issue both for governments and foundations, therefore indexes are published periodically. The list of sustainability focused indexes selected for this study and detailed information is provided in Table 2.

Table 2: List of Indexes

Index	Abbreviation	Foundation	Unit
Climate Change Performance Index	CCPI	Germanwatch	Rank
Environmental Performance Index	EPI	Yale University	Rank
Energy Trilemma Index	ETI	World Energy Council	Rank
Social Society Index - Human Wellbeing	SSI-HW	Social Society Foundation	Rank
Social Society Index - Environmental Wellbeing	SSI-EW	Social Society Foundation	Rank
Social Society Index - Economic Wellbeing	SSI-ECW	Social Society Foundation	Rank

The countries for this study are selected to cover the world's leading REC, CO_2 emissions and economy. From each continent at least one country is provided and most of the countries are either a European Union member or OECD member. Apart from this, some countries which are not in both categories such as, China, Brazil, and India etc. are added in means of foreseeing the world's situation for sustainability. In total, 25 countries are selected and ranked according to variables and indexes.

A rank list for REC, CO_2 emissions, and GDP is formed for selected 25 countries. With the aim of consistency, each variable is divided to countries' population and after getting per capita results the rank list is created. The rank lists of indicators are created according to their score on indexes and sorted for the selected 25 countries meaning that each rank list is from 1-25, not the original position for the variable and index. For example, if France and Sweden are 3rd and 6th country on actual CCPI report, these countries were sorted as 1st and 2nd

order in this study, respectively. Table 3 shows all rank lists of 25 countries for variables and indexes in alphabetical order.

According to the rank list of countries, Turkey has low ranks on variables when compared to countries like Finland, Netherlands, Norway, Denmark, Greece and Ukraine.

These countries except Ukraine and Greece are also located with high ranks on indexes' and it can be thought that these countries achieved sustainability. On the other hand, Greece shows a good performance on environment focused indicators namely, CCPI, SSI-EW and EPI. However, Turkey cannot be considered having a good environmental performance according to index rankings. It is obvious that Turkey must take progressive steps to increase its environmental performance. The best rank of Turkey is SSI-ECW with 7th order. However, this does not alter the fact that Turkey must change its environmental politics.

Table 3: Rank List of Countries

Country	REC	CO_2	GDP	CCPI	EPI	ETI	HW	EW	ECW
Australia	20	12	13	22	7	14	12	24	4
Brazil	4	10	7	16	18	20	24	4	20
Canada	6	12	13	22	10	12	11	25	18
China	1	1	2	19	24	24	21	15	12
Denmark	21	25	22	4	3	1	6	10	3
France	10	17	5	1	5	5	9	12	15
Finland	19	22	23	12	1	7	1	18	8
Germany	7	6	4	11	13	4	2	19	6
Greece	25	21	24	8	9	15	15	6	25
India	2	3	8	6	25	25	23	3	17
Indonesia	5	9	16	7	23	23	20	1	13
Italy	8	16	9	5	12	11	16	2	16
Japan	9	5	3	25	16	13	8	17	21
Mexico	14	11	15	10	19	19	22	7	9
Netherlands	23	20	18	9	15	3	3	20	10
Norway	16	23	20	15	8	6	4	16	1
Russia	11	4	11	21	14	17	19	23	11
South Africa	15	13	21	16	21	22	25	11	23
South Korea	22	7	14	24	20	16	10	22	5
Spain	12	18	12	14	4	9	14	5	22
Sweden	13	24	19	2	2	2	5	14	2
Turkey	18	15	17	20	22	18	18	13	7
Ukraine	24	19	25	18	17	21	13	8	24
UK	17	14	6	3	6	8	5	14	2
USA	3	2	1	17	11	10	17	21	19

4. Sustainability Focused Indexes

In recent years, the importance of sustainability force governments to take promotive action on renewable energy and preventive action CO_2 emissions policies [14]. Besides, for the evaluation of policies OECD, European Union, World Bank and similar organizations provide measurements depend on energy, environment and economy [15]. Apart from this, organizations and foundations publish indexes using different indicators and weighting systems. In this study, six sustainability focused indexes (CCPI, EPI, ETI, SSI-HW, SSI-EW, and SSI-ECW) are selected based on covering research variables (REC, CO_2 emissions and GDP).

4.1. Climate Change Performance Index (CCPI)

Germanwatch and Climate Action Network Europe publish CCPI results to create social and political pressure on countries every year. The index evaluates and compares the climate change performance of 58 countries [16]. The indicators and their weights on calculation is shown at Table 4

Table 4: Indicators of CCPI [16]

Indicator	Weight (%)
Emission Level (Primary Energy Supply per Capita (%7,5), CO_2 Emission per Capita (%7,5), Target-Performance Comparison (%10), Emissions from Deforestation per Capita (%5))	**30**
Emissions Development (CO_2 Emissions from Electricity and Heat Production (%10), CO_2 Emissions from Manufacturing and Industry (%8), CO_2 Emissions from Residential Use (%8), CO_2 Emissions from Aviation (%4))	**30**
Renewable Energy (Share of Renewables in TPES (%2), Development of Energy Supply from Renewables (%8))	**10**
Energy Efficiency (Efficiency Level (%5), Efficiency Trend (%5))	**10**
Climate Policy (International Policies (%10), National Policies (%10))	**20**

It is seen from Table 4 that a major share of evaluation includes level and development of CO_2 emissions. It is likely to obtain a negative strong correlation between CO_2 emissions and CCPI due to this reason. Although renewable energy has a small weight on evaluation, meaning that a weak correlation might be seen also. Because, the index does not contain any economic indicator, a correlation between GDP and CCPI is not expected.

4.2. Environmental Performance Index (EPI)

EPI ranks countries on their performance of environmental issues, which are protection of human health and protection of ecosystem [17]. It also evaluates agreed national targets and how far these targets are achieved. Therefore, The United Nations Sustainable Development Goals (SDGs) and EPI together is an important

indicator to represent the absence of these targets. The indicators and their weights of EPI are shown at Table 5. The indicators of EPI are mostly related with sustainable development and climate change mitigation. Therefore, a strong positive correlation is expected between GDP and EPI because economic growth is one of the key factors to achieve sustainable development. Also, these indicators can be considered as the feature of developed countries and therefore, GDP has a primary effect on this index. In addition, renewable energy is also another important factor, but this index is not able to represent any effects of renewables due to absence of energy related indicators. Although this may provide a weak correlation between REC and EPI.

Table 5: Indicators of EPI [17]

	Indicator	**Weight (%)**
Ecosystem Vitality (50%)	Climate & Energy (Trend in Carbon Intensity)	12,5
	Biodiversity & Habitat (Species Protection, Terrestrial Biome Protection, Marine Protected Areas)	12,5
	Fisheries (Fish Stocks)	2,5
	Forests (Tree Cover Loss)	5
	Agriculture (Nitrogen Balance, Nitrogen Use Efficiency)	5
	Water Resource (Waste Water Treatment)	12,5
Environmental Health (50%)	Health Impacts (Environmental Risk Exposure)	16,66
	Air Quality (Household Air Quality, Air Pollution avg. exp. to Particular Matters, Air Pollution avg. exp. To NO_2)	16,66
	Water & Sanitation (Unsafe Drinking Water, Unsafe Sanitation)	16,66

4.3. Energy Trilemma Index (ETI)

The World Energy Council prepares annual publication for the competitive analysis of 128 countries on energy sustainability. The World Energy Trilemma Index considers three pillars as a primary context which are energy security, energy equity and environmental sustainability [18]. The indicators and their weights of the pillars are shown at Table 6 where each indicator has a sub-indicator with equal weight.

In addition to these indicators, Country Context is also considered and evaluated into the calculation methodology for final rankings. Country Context has 10% shares and includes:

- Coherent Policy Framework (2%),
- Stable Regulatory Environment (2%),
- Initiatives that enable R&D (2%),
- Ability of Investment (2%),
- Air pollution, land and water impact (2%).

A positive strong correlation is expected between ETI and GDP. In addition, it is also expected to find a strong correlation between REC and ETI due the effect of renewables on energy related indicators.

Especially, renewable energy consumption and energy security has an important relationship because renewables can be operated and stored at local places and it decreases the energy dependency, consequently. Moreover, renewables have also positive effect on energy equity due to the ability of existence across any country.

Table 6: Three Pillars of Energy Security [18]

	Indicator	**Weight (%)**
Energy Security (30%)	Security of Energy Supply (Diversity of Primary Energy Supply, Energy Consumption in Relation to GDP, Import Dependence)	15
	Resilience (Diversity of Electric Generation, Energy Storage, Preparedness (Human Factor))	15
Energy Equity (30%)	Accessibility (Access to Electricity, Access to Clean Cooking)	10
	Quality of Supply (Quality of Electric Supply, Quality of supply in rural vs. urban)	10
	Affordability (Electricity Prices, Gasoline and Diesel Price, Natural Gas Prices)	10
Energy Equity (30%)	Energy Resource Productivity (Final Energy Intensity, Efficiency of Power Generation)	10
	GHG Emissions (GHG Emission Trend, Change in Forest Area)	10
	CO_2 Emissions (CO_2 Intensity, CO_2 Emissions per Capita, CO_2 from Electricity Generation)	10

4.4. Social Society Index (SSI)

Sustainable Society Foundation publishes Sustainable Society Index (SSI) biyearly to create awareness to promote sustainability. SSI especially integrates Human Wellbeing (SSI-HW), Environmental Wellbeing (SSI-EW) and Economic Wellbeing (SSI-ECW) because these are the three pillars of sustainability [19]. The framework and indicators of each wellbeing dimension is shown at Table 7.

It is likely to expect that there is a negative correlation between CO_2 emissions and SSI-EW, because the increase on CO_2 emissions boosts the greenhouse gases and shows the decreased share of renewable energies on total consumption. On the other hand, it is also expected that GDP has an important effect on all of these wellbeing dimensions and is the key factor to development and SSI-ECW. It is seen on many studies that GDP and CO_2 emissions has a relationship and they can boost each other, meaning that there might also be a negative correlation between GDP and SSI-EW.

Table 7: SSI Framework & Indicators [20]

Human Wellbeing	**Environmental Wellbeing**	**Economic Wellbeing**
Basic needs • *Sufficient Food* • *Sufficient Drink* • *Safe Sanitation*	Healthy Environment • *Air Quality – humans* • *Air Quality – nature* • *Surface Water Quality*	Preparation for the Future • *Material Consumption* • *Organic Farming* • *Genuine Savings*
Personal Development & Health • *Healthy Life* • *Education Opportunities* • *Gender Equality*	Climate & Energy • *Renewable Energy* • *Emission of GHGs* • *Energy Consumption*	Economy • *Gross Domestic Product* • *Employment Public Debt*
Well-balanced Society • *Good Governance* • *Income Distribution* • *Population Growth*	Natural Resources • *Renewable Water Resources* • *Forest Area* • *Biodiversity*	

5. Comparative Analysis of Indexes by Research Variables

In order to create a competitive analyze for the selected indexes and their relationships between variables, the scatter plot matrix and Spearman's test results will be presented for each variable. In this study, it is expected to obtain similar results with scatter plot matrices and Spearman's test results.

5.1. Comparison on correlations by REC

The first analysis was applied to the effects of renewables on selected indexes. As it is mentioned in the previous section, it is expected to find a correlation with positive vector for EPI and ETI. The scatter plots of indexes is shown at Figure 1. According to plots, the expected correlation will also likely to occur on Spearman's test.

Spearman's test results prove the expected correlations mentioned at Table 8. The strong correlation was found between REC and EPI and the moderate correlation was also found regarding to ETI. These findings are an evidence to the existence of monotonic correlations. In addition to these results, a weak correlation was also investigated the regarding to CCPI and SSI-HW. The monotonic correlations for ETI, EPI and a weak

correlation for CCPI show no surprise because renewable energy is a direct indicator for these indexes. Although human wellbeing has no direct indicator on renewables, the strength of correlation between SSI-HW and REC is higher than predicted. This value is almost in the limits of moderate correlation which can show a monotonic attribute and renewables can be considered as an important factor to achieve sustainability on social area due to this reason. This finding is invaluable because it shows that investment of renewable energy technologies does not only affect the environmental issues, it also affects the development of social health and equity.

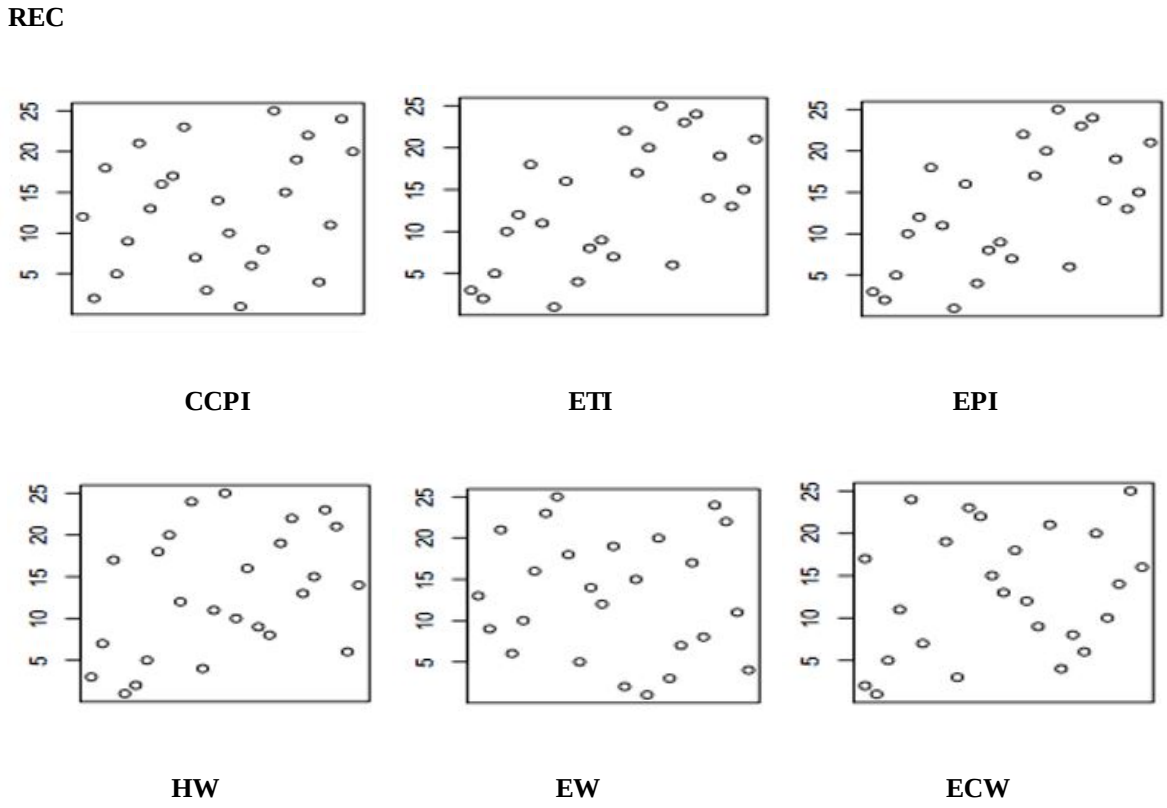

Figure 1: Scatter Plots of REC with Indexes

Table 8: Result of Correlations by REC

	CCPI	EPI	ETI	SSI-HW	SSI-EW	SSI-ECW
Cor. Coef.	0,24153	0,60769	0,56846	0,3846	0,1084	0,1708
p-value	0,24475	0,00086	0,00215	0,0576	0,6058	0,4142
Significance	No	**Yes**	**Yes**	No	No	No

5.2. Comparison on correlations by CO_2

The second analysis was applied to get result for the relationship between CO_2 emissions and indexes. As expected, CO_2 emissions has a negative effect on the performance of CCPI and EW. The scatter plots are shown

at Figure 2 and it is seen that the findings support those expectations.

CO_2

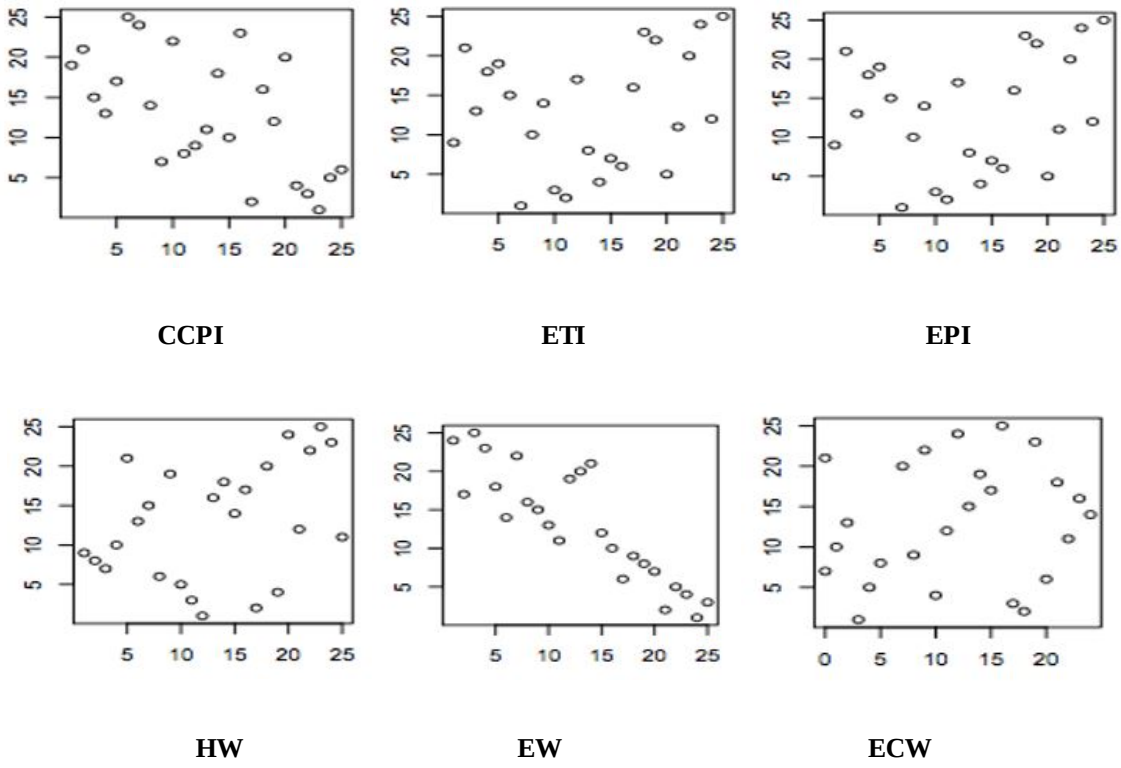

Figure 2: Scatter Plots of CO_2 with Indexes

Spearman's results of indexes by CO_2 emissions are shown at Table 9. The fact that the increase on CO_2 emissions is the key factor of global warming and climate change was proven by the Spearman's test results because the very strong negative correlation is found between CO_2 emission and SSI-EW. The primary aim should be to achieve the targeted emission levels that are accepted on Paris Agreement to mitigate climate change and create sustainable environment. Moreover, moderate (almost strong) negative correlation is also found the regarding to CCPI and it is clear that CO_2 emissions are evidence to show which country contributes for climate change mitigation. This may create a pressure on countries to achieve their targeted emission levels.

Table 9: Result of Correlations by CO_2

	CCPI	**EPI**	**ETI**	**SSI-HW**	**SSI-EW**	**SSI-ECW**
Cor. Coef.	-0,591	0,22461	0,27461	0,379	-0,874	0,171
p-value	0,00190	0,26094	0,16673	0,061	0,0019	0,414
Significance	**Yes**	No	No	No	**Yes**	No

The surprising result was investigated due to almost moderate level of correlation coefficient between CO_2

emissions and SSI-HW because a similar correlation is also detected between REC and SSI-HW before. This result may be explained by the Spearman's test result of GDP related correlations because the relationship between economic growth and CO_2 emissions is accepted in literature. Therefore, as economic growth is the key factor for sustainable development of all areas, the correlation between CO_2 emission and SSI-HW can also be acceptable.

5.3. Comparison on correlations by GDP

Finally, the effect of economic growth to selected indexes was analyzed. There is no doubt that there might be strong correlations between GDP and all indexes, because most indicators are the feature of developed countries. The scatter plot result is shown at Figure 3. The result shows that economic growth is an important factor on the performance of all indexes, except CCPI.

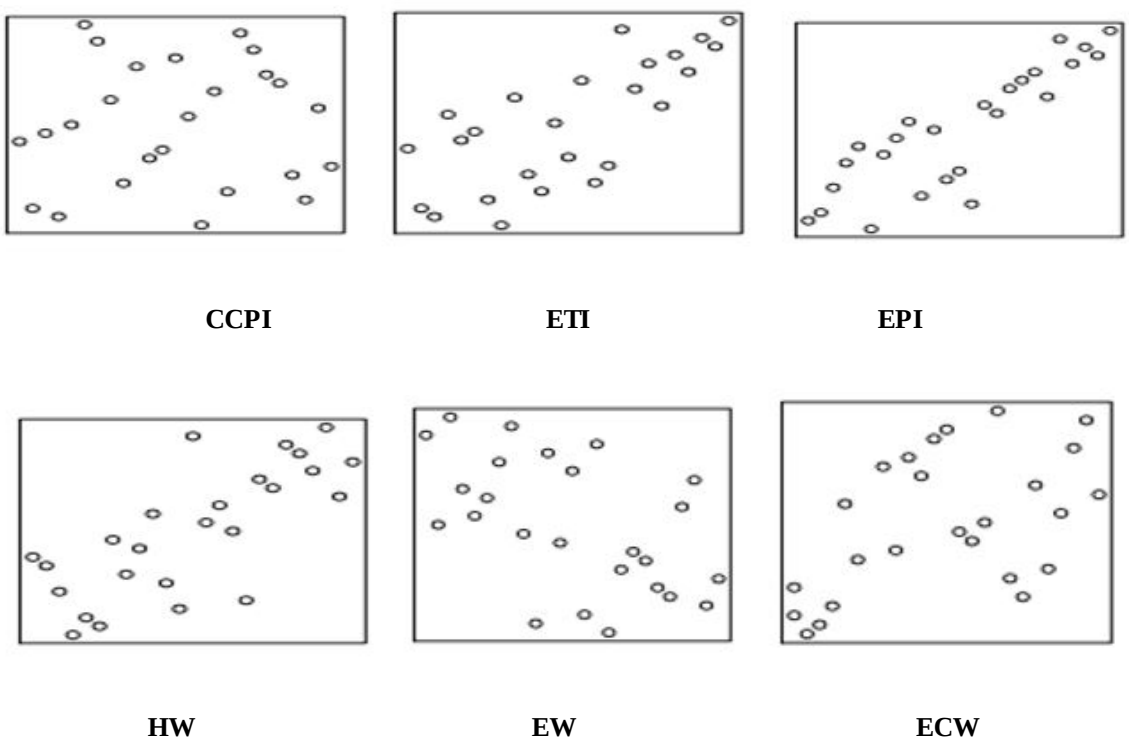

Figure 3: Scatter Plots of GDP with Indexes

Spearman's test result is shown at Table 10. As it is visible on scatter plots, the Spearman's test is also a proof to show that economic growth is key component for all selected indexes, except CCPI. A very strong positive correlation the regarding to ETI and with strong correlations regarding to EPI and SSI-HW were found. Firstly, the correlation between GDP and SSI-HW supports the correlation between CO_2 and SSI-HW. These results may clarify the relationship between economic growth and CO_2 emissions. In addition, the moderate negative correlation between GDP and SSI-EW is also an important evidence that economic growth boost CO_2 emissions and has a negative impact on environmental area. Another important result is that there is no monotonic

correlation between GDP and CCPI because according to Germanwatch the effort to mitigate climate change is not related to the development of economic situation. So that the developed countries have to get more responsibilities and increase their funds to enhance their damages on environment while economically developing countries have a significant effort.

Table 10: Result of Correlations by GDP

	CCPI	**EPI**	**ETI**	**SSI-HW**	**SSI-EW**	**SSI-ECW**
Cor. Coef.	0,523	0,7407	0,8638	0,7453	-0,524	0,502
p-value	0,8038	1,31E-05	1,28E-08	0,0001	0,0071	0,015
Significance	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

6. Discussions and Conclusion

In this study, the relationship between selected variables (GDP, REC, and CO_2 emissions) and the selected indexes (CCPI, ETI, EPI, HW, EW, ECW) was investigated for the selected 25 countries. In order to get a rational result, the scatter plot and Spearman's Correlation Test was applied for both variables. The main purpose of the study was the revealing if there is any correlation between these variables and indexes and if there is, to create a prediction to see which variables have an effect on which index.

As a first analysis, the correlation regarding to REC was analyzed. The findings show that renewable energy has a monotonic correlation between ETI and EPI. Therefore, it can be easily said that in order to achieve environmental sustainability, renewable energy sources are the key factor and must not be ignored. In addition, it was also investigated that a moderate correlation exists regarding to SSI-HW and it is an evidence to show that renewables have not only environmental effect, but they also contributed to energy consumption in socially sustainable countries. As conclusion, these results clarify that the development on renewable energy will be helpful to make our world cleaner, greener and more equitable.

Secondly, the correlation between CO_2 emissions and the selected indexes was investigated. The striking result was found that there are very strong and moderate (almost strong) negative correlations regarding to SSI-EW and CCPI, respectively. Therefore, it is clear to suggest that the decrease on CO_2 emissions is one of the primary factors to achieve sustainable environment. It is seen that CO_2 emissions is the key factor for global warming and climate change and its harm on the world must be prevented as soon as possible.

Finally, the effect of GDP on these indexes was analyzed as a last variable. Monotonic positive correlations with regarding to ETI, EPI, SSI-HW and SSI-ECW while a negative correlation is found regarding to SSI-EW. The only index which no correlation exist for GDP is CCPI. According to these results, it is seen clearly that economic growth has an important effect on many indexes and there is no doubt that economic growth is key factor to achieve sustainable development because sustainability can be considered as the feature of developed countries. On the other hand, the surprising result is that there is no correlation between CCPI and GDP. This is

because CCPI does not include economic indicators in its framework.

The results of this study suggests that the increase on renewable energy sources and the decrease on CO_2 emissions are the main factors for obtaining environmental targets which are mitigating climate change and achieving sustainable environment. Moreover, these results are also proof that economic growth is not only necessity to create an effort for these targets although it has an important effect. Therefore, the developed countries should not have an excuse to achieve the targets accepted on Paris Agreement and create promising funds to undeveloped countries.

It is expected that this study will be helpful on the subject of climate change and sustainability for the literature. It is seen that the research variables effect sustainability and environmental performance. This is a preliminary study to investigate is there is any causal relationship between research variables. So that, a future study for assessing the relationship between REC, CO_2 emissions, and GDP will be conducted applying different methods.

References

[1] European Renewable Energy Council. "Renewable Energy – The Solution to Climate Change". European Renewable Energy Council". Internet:

http://www.seai.ie/Publications/Renewables_Publications_/Energy_RD_D/RESolutiontoclimatechange.pdf [June 06, 2017]

[2] K. Menyah and W. Y. Rufael. "Energy consumption, pollutant emissions and economic growth in South Africa", Energy Economics, vol. 32, pp. 1374-1382, Nov. 2010.

[3] A.A. Selam, M.Ö. Arıoğlu Akan, S.Ü. Oktay Fırat, S. Özel, and M. Er. "An evaluation of renewable energy indicators within the sustainability framework", in Proc. IAFOR, 2014, pp. 83-94.

[4] K. Saidi and M.B. Mbarek, "Nuclear energy, renewable energy, CO_2 emissions and economic growth for nine developed countries: Evidence from panel Granger causality tests", Progress in Nuclear Energy, vol. 88, pp. 364-374, Apr. 2016.

[5] M. Sebri and O.B.Salha, "On the causal dynamics between economic growth, renewable energy consumption, CO_2 emissions and trade openness: Fresh evidence from BRICS countries", Renewable and Sustainable Energy Reviews vol. 39, pp. 14-23, Nov. 2014.

[6] J.P.C. Bento and V. Moutinho. "CO_2 emissions, non-renewable and renewable electricity production, economic growth and international trade in Italy", Renewable and Sustainable Energy Reviews, vol. 55 pp. 142-155, Mar. 2016.

[7] M. Bhattacharya, S.A. Churchill and S.R. Paramati. "The dynamic impact of renewable energy and institutions on economic output and CO_2 emissions across regions", Renewable Energy, vol. 11, pp. 157-167, Oct. 2017

[8] J. Hauke and T. Kossowski. "Comparison of values of Pearson's and Spearman's Correlation Coefficients on the same dataset", Quaestiones Geographicae, vol. 30, pp. 87-93. Jun. 2011.

[9] C. Hattam, T. Hooper and E. Papathanasopoulou. "A well-being framework for impact evaluation: The case of the UK offshore industry", Marine Policy, vol. 78, pp. 122-131, Apr. 2017.

[10] E. Mboumboue and D. Njomo. "Potential contribution of renewables to the improvement of living conditions of poor rural households in developing countries: Cameroon's case study", Renewable and Sustainable Energy Reviews, vol. 61, pp. 266-279, Aug. 2016.

[11] X. Zuo, H. Hua, Z. Dong and C. Hao. "Environmental Performance Index at the Provincial Level for China 2006-2011", Ecological Indicators, vol. 75, pp. 48-56, Apr. 2017.

[12] J.N.V. Lucas, G.E. Frances and E.S.M. Gonzales. "Energy security and renewable energy deployment in the EU: Liaisons dangereuses or virtuous circle?", Renewable and Sustainable Energy Reviews, vol. 62, pp. 1032-1046, Sep. 2017.

[13] K. Zaman and M.A. Moemen. "Energy consumption, carbon dioxide emissions and economic growth: Evaluating alternative and plausible environmental hypothesis for sustainable growth", Renewable and Sustainable Energy Reviews, vol. 74, pp. 119-1130. Jul. 2017.

[14] M. Ö. Arıoğlu Akan, A.A. Selam, S.Ü. Oktay Fırat, M. Er Kara and S. Özel. "A comparative analysis of renewable energy use and policies: Global and Turkish perspectives", Sustainability, vol. 7, pp. 16379-16407, Dec. 2015.

[15] M. Ö. Arıoğlu Akan, A.A. Selam and S.Ü. Oktay Fırat. "Renewable Energy Sources: Comparison of Their Use and Respective Policies on a Global Scale", in Handbook of Research on Green Economic Development Initiatives and Strategies, 1st ed., vol. 1. M.M. Erdoğdu, T. Arun and I.H. Ahmad, Ed. Pennsylvania: IGI Global, 2016, pp. 238-269.

[16] J. Burck, F. Marten C. Bals, A. Dertinger and T. Uhlich. (2016, Nov 1) Climate Change Performance Index 2017 Results. (1st edition). [On-line]. 1(1). Available: www.germanwatch.org/en/ccpi [June 1, 2017].

[17] A. Hsu et. al. "2016 Environmental Performance Index" Internet: http://epi.yale.edu/sites/default/files/2016EPI_Full_Report_opt.pdf [June 1, 2017].

[18] World Energy Council. World Energy Trilemma Index 2016. (1st edition). [On-line]. 1(1). Available: https://trilemma.worldenergy.org/reports/main/2016/2016%20Energy%20Trilemma%20Index.pdf [June 1, 2017].

[19] Sustainable Society Foundation. Main Results 2016 of SSI. (1st edition). [On-line]. 1(1). Available: www.ssfindex.com/ssi [June 1, 2017].

[20] M.Ö. Arıoğlu Akan and A.A. Selam "Assessment of social sustainability using Social Society Index: A clustering application", accepted for presentation at the 5th Int. Conf. od Sustainable Development, Rome, Italy, 2017.