The Influence of Land Utilization and Urbanization, on Environmental Decay in G-20 Countries: Novel Implications for Sustainable Urban Growth

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Abstract: The declining quality of utilized land is due to tectonic forces and exogenic procession, which creates an alarming situation, globally. This research investigates land utilization and greenhouse gas emissions in G-20 countries from 1990 to 2019. The reason behind the data sample from 1990 to 2019 is the availability of data and synchronization of variables for the analytical process. The annual data is deprived of the World Development Indicator. This study contributes to determining the dynamic relationship among total greenhouse gases, land utilization, urban development, economic development, and agricultural land by employing advanced techniques, FMOLS, DOLS and VECM. The conducting analysis tests the long-run relationship's robustness and causal trend after checking cross-sectional dependency and integration level. The Kao corroborated the presence of cointegration while long-run relationship authenticated by FMOLS and DOLS. The VEC model revealed that total greenhouse gases are unidirectionally related to land utilization, urban development and agricultural land. This research is valuable for researchers, agronomists, soil scientists, environmentalists, government, and policymakers seeking the enhancement of environmental quality, reduction of greenhouse gas emissions, reductions in soil erosion and improvement of green production methods that target sustainable development goals.

Keywords: Land Utilization; Urban Development; Total Greenhouse Gases; sustainable development; G20 countries

1 Introduction

Globally, cereal lands declined 50% its productivity due to soil, water and wind erosion. According to a thoroughgoing guesstimate, soil erosion takes US$400 billion for recovering the loss of 75 billion tons of fertile soil [1]. The agronomists and soil scientists considered a US$70 per person loss globally [2] [3]. In addition, the land cover changed and faced degradation due to greenhouse gas emissions. The member countries of G-20 are a presented fragmented picture on the Environmental Performance Index (EPI) map [4]. The environmental performance index report of Y-2021 declared that the highest performer in degradation of environment from G20 countries is UK and India along with the EU as a whole. The high rating of GHG emissions category is attained by India, the UK and France. France joined the UK and India in the last two years to increase GHG emissions. Global warming and GHG emissions have expanded rapidly, and worldly the countries are trying to attain a zero-carbon economy. The G20 countries were established a Green Finance Study Group (GFSG) who tracks the institutions and markets barriers to green finance. The GFSG stream is divided into five subgroups, i.e., green bonds experts & green institutional investors, by seeking the help of the Organization for Economic Cooperation and Development (OECD) [5]. The OECD, with the collaboration of GFSG has established a vast system to mobilize private capital for green financing. The structural policies and systematic approach were adopted by Italy and introduced GFSG in 2021 for restructuring their financial work stream with the help of OECD. The indexing process is unsure about the increasing and decreasing GHG emissions [6]. However, there is still room to shape the sustainable environment, introduce strategies of recovery packages, and many more policies are under discussion. Energy production and consumption comes from undeveloped and unsustainable methods in virtually 11 members, of the G20 countries.

The major contributors of unsustainable energy methods in G20 are Turkey (Rank: 172, EPI Score: 26.30), Mexico (Rank: 73, EPI Score: 45.50), India (Rank: 180, EPI Score: 18.90), South Africa (Rank: 116, EPI Score:37.20), Indonesia (Rank: 164, EPI Score: 28.20), Turkey (Rank:172, EPI Score: 26.30), and the United States (Rank: 43, EPI Score:51.10). The figure-1 is presenting the whole environmental situation of G20 countries, which displayed the toxic and unsustainable area by red color. Land utilization is essential due to its strong link with agronomic productivity, food security, quality of life and environmental sustainability [7] [8]. Land degradation and food production decay can be masked by the adaptation of advanced technology and input restoration [9] [10]. The use and abuse of pesticides directly influence land performance and land degradation [11]. Insecticides, fungicides, herbicides, rodents, molluscicides, nematicides, plant growth regulators and others are good to use in minor quantities. Excessive use degrades the land and soil quality and affects beneficial soil microorganisms with human health as slow poison [12] [13]. Land is a non-renewable resource at a human time scale. Some human-based activities like reducing effective rooting path influence land quality adversely and these activities are irreversible [14].

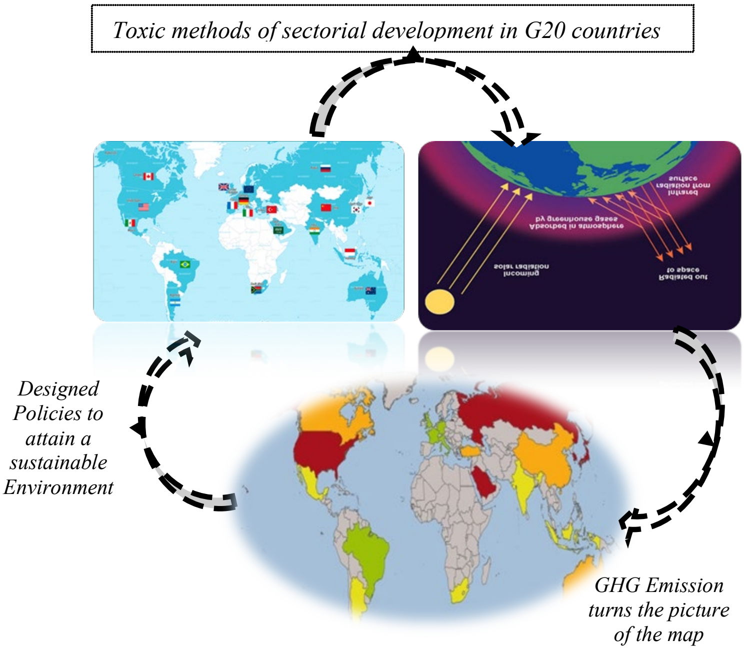

Figure 1
The impact of Greenhouse gases on G-20 Countries

The innovatory and distinctive fragment of this research is to explore the influential capability of different sectors of development on greenhouse gases emission. The excessive use of land in G20 countries has worsened environmental sustainability, which creates an alarming situation toward food security and ecological sustainability. The World Business Council for Sustainable Development (WBCSD) also considered reducing the fertility of the land and increasing environmental pollution. The agronomists, environmentalists and economists are working on sustainable development of cultivated land. This research attempts to fill the gap and collaborate to solve this global issue, i.e., optimization of land productivity with environmental sustainability. The determinants are sectored as dependent, independent and control variables. Total greenhouse gases emission is performing as dependent variables as well as the leading authorities of environmental deterioration. Land utilization and urban development is representative of variables' independence. Land utilization is a key to people's productive land and living standard of people while urban development is the commentating factor of population, projections, and facilitation of urban areas [10] [11] [15] [16]. Economic development and the

Crop Production Index are listed as control variables. The panel data of G20 countries are approached from 1990 to 2018 for determining the relationship among variables. The G20 countries have a mixture of developed, emerging, and developing economies; that's why this research will be unique and exciting. It's easy to present an individual country, but it's a hectic task to increase the level of other members equivalently as a group [17]. This research also enlightened the way of thinking and visualization by enhancing a broad view. The focused groups of countries have gone through divergent environmental, economic, and social phases, so this research can be used the other countries on the globe that have the same situation. The casual relationship and trending behavior of variables toward the environment are measured using FMOLS, DOLS and VECM techniques. Furthermore, this research provides comprehensive suggestions to boost the quality of the environment in G20 countries.

2 Literature Review

Land and soil aren't non-renewable or replaceable resources, but 95% of global food production with ecosystem services like biomass production, contaminants filtration, mass transfer and circulating energy between spheres are on its credit [18] [19]. The intensive toxic change in climate, resources depletion, and the rapid growth of population, dietary patterns, and productive agronomic land has become the reason for unprecedented stresses and shocks in the global food system [19] [20]. Kang et al., [20] determined a significant relationship between land degradation, climate variation and human activities by utilizing the Normalized Difference Vegetation Index (NDVI) and Net Primary Productivity (NPP) which are based on the Euclidean distance method. The findings of this research flourish the quantitative relationship between climate change and human activities by generating Land Degradation and Development Index (LDDI). Human activities are dominantly influenced by land degradation as compared to climate changes (temperature & precipitation) [6] [21]. The production of land is part of the daily use of every human being. On one side, land degradation due to the overuse of pesticides is poisoning; on the other side, land infertility becomes the reason for food shortages. The health of the soil and productive land is as important for human beings as its production. The persistent decline in terrestrial ecosystem productivity features vegetation degradation, water loss, soil erosion and desertification [5], but almost 3.2 billion in urban development & populated areas are influenced globally. This approximation discovered that human activities degrade 30% globally and 40% land of developing countries [22]. The greenhouse effect and ecosystem carelessness are lost \$6.3 trillion, and 73% of dry lands are affected by the deprivation process. Agro-pastoral areas in G20 countries have been targeted at a large scale as well as the forestlands and grasslands are shortened. This research has screened peat land degradation and development in

Peninsular Malaysia and the islands of Sumatra and Borneo and covered the western half of insular Southeast Asia, and calculated the global contribution of CO_2 emission by land utilization. The research data has protected the period from 1990 to 2008. The facts and figures are derived from satellite pictures of high-resolution Landsat (30 m spatial resolution) and Satellite Pour l'Observation de la Terre (SPOT; 10–20 m). Peat swamp forestry ecosystems have observed dramatic reduction and degradation by land cover changes since 1990. Shockingly, within 20 years, almost 5.1 million hectares of peat land have been deforested, and the remaining forests have been logged selectively in bulk quantity.

The secondary growth of unmanaged habitats had doubled in size within no time, and the proliferation of peat land and industrial plantation comprised a quarter of total land (0.3 Mha-2.3 Mha; 2% -15%). According to conservative estimation, the minimum carbon emission in the atmosphere is 1.5Gt from 1990 due to changes in land utilization. The yearly quota of peat land research areas is at least 81Mt of carbon emission per year, equal to 300 Mt of CO_2 emissions owing to peat land alone. This figurative conclusion has indicated that peat land degradation and development have been endangering in insular Southeast Asia over the last two decades. Furthermore, the survival of Southeast Asian peat-swamp forest ecosystems has also resulted in significant global carbon emissions, creating a constant source of carbon dioxide [23]. A comprehensive research work of an Indian city named Ahmedabad has enlightened the way to assess land utilization efficiency and offered [24] a more nuanced view of land consumption patterns in the public and private sectors [25]. This research also focused on how sub-optimal land development patterns emerge in a rapidly growing city. The factors selected to determine the relationship and development variations are public streets, building footprints, and public & remote open areas. The inefficiency of land use with less land in the public domain and more used as private open spaces (mainly as margins and setbacks) is that the output of analytical procession comes from excessive fragmentation. To enhance the efficiency of land, Indian cities should rationalize their development policies and adopt output-based strategies.

3 Data Screening and Analytical Methods

3.1 Data Screening

The research data is gathered from the World Development Indicator (WDI) from 1990 through 2019 for G-20 countries. The scalariform of variables and their identifiers total greenhouse gas emissions (TGE), land under cereal production (LU), Urbanization population (UD), economic development (ED), and Agricultural Land (AL) which are presented in table-1 with auxiliary details.

The variables are prismatically performed their roles in the analytical process, e.g., dependent (TGE), independent (LU & UD) and control variables (GDP & AL). In addition, the data sheets are used for analysis after the natural log to circumlocution the defalcation of data like heteroskedasticity and non-linear modeling.

Table 1

Variable Description

Symbol	Variables	Unit of Measurement
TGE	Total Greenhouse Gases Emissions	Total greenhouse gas emissions (kt of CO_2 equivalent)
LU	Land Utilization	Land under cereal production (hectares)
UD	Urban Development	Urban population
ED	Economic Development	GDP per capita (current US$)
AL	Agricultural Land	Percentage of Land Area
Research data is extracted from the World Bank (2022)		

3.2 Analytical Methods

This analytical process attempts to identify the nexus among total greenhouse gases (TGE), land utilization (LU), urban development (UD), economic development (ED), and Agricultural Land (AL). The flowchart of analytical procession and variables are presented in figure 2. The analysis will undergo into four sections: firstly, The Pesaran CD test is employed to govern the cross-sectional dependent or independent variables. Secondly, the unit root test is used in conjunction with the Pesaran CD test [44]. Thirdly, the cointegration relation is determined by employing the Kao test. Fourthly, the FMOLS and DOLS are used to evaluate long-run relationships, whilst the VECM is utilized to determine Granger Causality in the long and short run.

3.2.1 Cross-Section Dependence Test

The Pesaran CD test is used to ensure that the unit root test produces accurate results. The equational structure of the panel model for the Pesaran CD is presented as follows:

$$y_{it} = \alpha_i + \beta_{it} Z_{it} + u_{it}$$

In the Pesaran Cross-sectional Dependency equation, $i = 1,2,\dots,N$ is the subscript of each land utilizing G-20 countries individually for time dimensions $t = 1,2,\dots,T$. The parameter of α_i is archetypal of the constant evaluation of y_{it} causal variables β_{it} is used as a vector parameter, and the error term is denoted by u_{it} . The equational form of the null hypothesis is $H_0 = \gamma_{ij} = \gamma_{ji} = cor.(\mu_{it}, \mu_{jt}) = 0 \; for \; i \neq j$ which confirms no cross-sectional dependency while alternative hypothesis equational form is $H_a = \gamma_{ij} = \gamma_{ji} \neq 0 \; for \; i \neq j$ against the null hypothesis. The j[th] term is representative of autocorrelation coefficient. Previous literature witnessed divergent tests implementation as Friedman [26] and Breusch-Pagan LM [27]. Compared to Friedman [26] and Breusch-Pagan LM [27], the small data sample is more appropriately measured by the Pesaran CD test. The unit root test is checked stability and stationarity of selected series if the unit root test has existed in time series and it confirmed non-stationarity in data.

3.2.2 Unit-Root Test

The stationarity of the data series is checked by employing the ADF test for level and first difference [19]. The least-square method-based unit-root test for the individual intercept and the fundamental structured of ADF, PP [28], LLC & IPS [29] based on below mentioned equations as:

$$ADF{:}\, \Delta y_t = \alpha_0 + \alpha y_{t-1} + \sum_{i=1}^{p} \beta_j \Delta y_{t-i} + \varepsilon_t$$

$$PP{:}\, \Delta y_t = (p-1) y_{t-1} + \varepsilon_t$$

$$LLC{:}\, \Delta y_{it} = \emptyset_i y_{i,t-1} + z_{it}' \gamma_i + \sum_{j=1}^{p} \theta_{ij} \Delta y_{i,t-j} + \mu_{it}$$

$$IPS{:}\, \Delta y_{it} = \emptyset_i y_{i,t-1} + z_{it}' \gamma_i + \sum_{j=1}^{p_i} p_{i,j} \Delta y_{i,t-j} + \varepsilon_{it}$$

In above mentioned equations, the Δy_t is changing determinator of dependent variable concerning time.

The constant is denominated by α_0 and α is the coefficient of the preceding value. In the Phillips & Perron [28] the first difference operator is nominated with Δ while y_t for high order of autocorrelation and y_{t-1} for endogeneity concerning time. The equational structure of the Levin-Lin-Chu test is based on two parts; 1) a standard autoregressive parameter is shared by all panels. Because the parameter $\emptyset_i y_{i,t-1} + z_{it}' \gamma_i$ is likely to be plagued by serial correlation, 2) $\sum_{j=1}^{p} \theta_{ij} \Delta y_{i,t-j}$ is addressed the LLC augment model. This supplementary element of the model is employed to increase the dependent variable's lag.

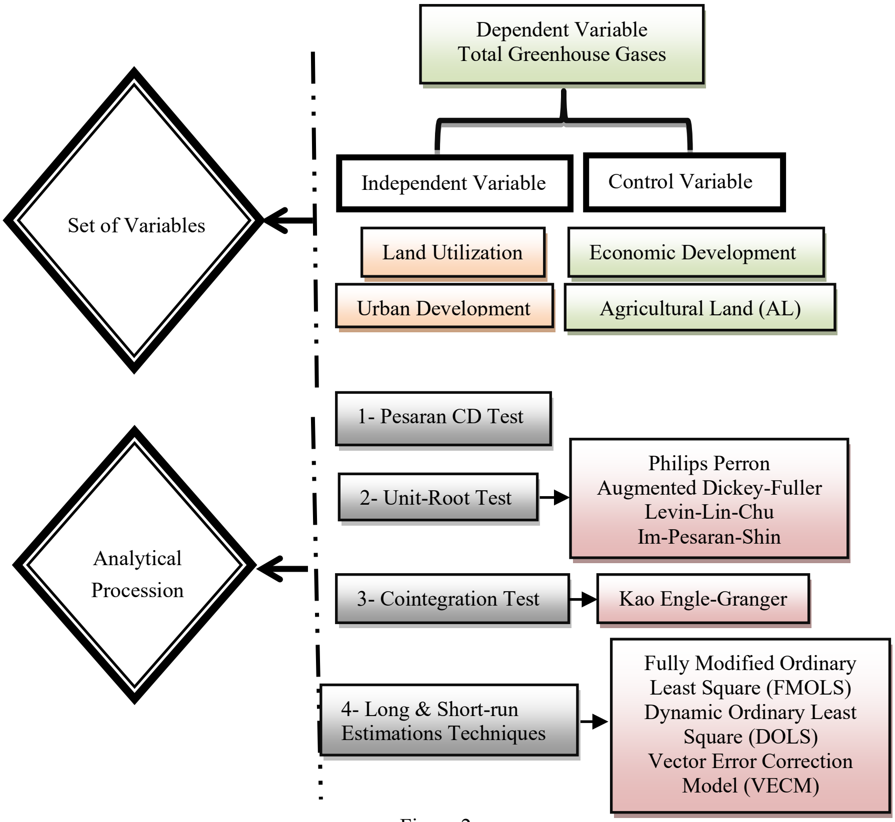

Figure 2
Flowchart of Variables and Analytical Techniques

The IPS test eliminates serial correlation and relaxes the premise of a shared autoregressive parameter, it is acceptable to shorten the data period. Furthermore, IPS does not require a balanced dataset. The equational part $\left(_{N(panel\ size),T(Sample)}^{N,T}\right) = N^{-1}\sum_{i=1}^{N} t_i(N,T)$ is representative of no serial correlation without using any lag option.

3.2.3 Cointegration Test

The Kao Engle-Granger based cointegration test is selected to check the cointegration relation of variables. The cross-section specific intercepts and homogeneous coefficients are the fundamentals of the Kao cointegration on the first stage regressor [30].

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}$$
$$y_{it} = y_{it-1} + u_{i,t}$$
$$x_{it} = x_{it-1} + \varepsilon_{it}$$

$$Covariance: w_{it} = \begin{bmatrix} u_{it} \\ \varepsilon_{it} \end{bmatrix} \text{ is estimated as } \hat{\sum} = \begin{bmatrix} \hat{\sigma}_u^2 & \hat{\sigma}_{u\varepsilon} \\ \hat{\sigma}_{u\varepsilon} & \hat{\sigma}_\varepsilon^2 \end{bmatrix} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} w_{it} w_{it}'$$

$$= \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{T}\sum_{t=1}^{T}(w_{it}w_{it}') + \frac{1}{T}\sum_{\tau=1}^{\infty} \mathrm{K}\left(\tau/_b\right)\sum_{t=\tau+1}^{T}(w_{it}w_{it-\tau}' + w_{it-\tau}w_{it}') \atop k = kernel\ nominator, b = bandwidth\right]$$

The heterogeneity and homogeneity are presented in equation as α_i and β_i. The trend coefficients are displayed as γ_i to zero. Kernel is the parameter of Long-run covariance estimation.

3.2.4 Fully-Modified & Dynamic Ordinary Least Square

The application of the cointegration equation has included the FMOLS, and DOLS approaches to check the long-run relationship among variables. The modification of autocorrelation and residual non-normality is possible under impartial conditions. The primary purpose of FMOLS was to measure parameters because the OLS term only deals with asymptotical biases [31] [32]. The implication of FMOLS and DOLS methods resolves the endogeneity issue and removes small samples' biases or provides accurate results without biases. The FMOLS facilitates the extension of the OLS panel setting and dynamic heterogeneity [33]. The FMOLS estimator is as follows:

$$\beta_{FMOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}X_{it}'\right]^{-1}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}\bar{y}_{it}^{+} - \gamma_{12}^{+'}\right)$$
$$Cointegrated\ variables: X_{it}, Y_{it}$$

The modified dependent variables are shown as $\bar{y}_{it}^{+}$ and $\bar{y}_{it}^{+} = (y_{it} - \bar{y}_{it}) - \hat{w}_{12}\Omega_{22}^{-1}\Delta_{22}$ and corrected serial correlation, Ω, Δ is long-run estimators. The DOLS method is a parametric economic method for determining the long-run relationship among coefficients [34]. The equational presentation of the DOLS model is as follows:

$$DOLS: y_t = a + bX_t + \sum_{i=-k}^{i=k} \emptyset_i \Delta X_{t+i} + \varepsilon_t$$

The long-term elasticity is captured by b; $\emptyset$ leads lag differences of I (1) regressor. Moreover, the endogeneity, autocorrelation and non-normal residuals adjustment is assisted by coefficients as nuisance parameters [35].

3.2.5 Vector Error Correction Model (VECM) Granger Causality

After confirming the cointegration relationship, VECM can investigate the causation direction of factors. The VECM modeling framework within a system of EC model used in this study is as follows:

$$\begin{bmatrix} \Delta lnTGO_t \\ \Delta lnLU_t \\ \Delta lnUD_t \\ \Delta lnED_t \\ \Delta lnCPI_t \end{bmatrix} = \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \end{bmatrix} + \begin{bmatrix} d_{11m} d_{12m} d_{13m} d_{14m} \\ d_{21m} d_{22m} d_{23m} d_{24m} \\ d_{31m} d_{32m} d_{33m} d_{34m} \\ d_{41m} d_{42m} d_{43m} d_{44m} \\ d_{51m} d_{52m} d_{53m} d_{54m} \end{bmatrix} \text{X} \begin{bmatrix} \Delta lnCO_{2t-1} \\ \Delta lnLU_{t-1} \\ \Delta lnUD_{t-1} \\ \Delta lnED_{t-1} \\ \Delta lnCPI_{t-1} \end{bmatrix} + \cdots +$$

$$\begin{bmatrix} d_{11n} d_{12n} d_{13n} d_{14n} \\ d_{21n} d_{22n} d_{23n} d_{24n} \\ d_{31n} d_{32n} d_{33n} d_{34n} \\ d_{41n} d_{42n} d_{43n} d_{44n} \\ d_{51n} d_{52n} d_{53n} d_{54n} \end{bmatrix} \text{X} \begin{bmatrix} \Delta lnTGO_{t-1} \\ \Delta lnLU_{t-1} \\ \Delta lnUD_{t-1} \\ \Delta lnED_{t-1} \\ \Delta lnCPI_{t-1} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{bmatrix} (ECM_{t-1}) + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix}$$

In the above model, coefficients $\lambda_1 - \lambda_7$ are representative of error correction terms, $\varepsilon_{1t} - \varepsilon_{7t}$ denoted homoscedastic disturbance term, ECM_{t-1} displays the long-term equilibrium and the speed of adjustment from the short-term equilibrium to the long-term equilibrium. It is possible to determine the short-term causation and its direction using the Wald test's first difference statistics [19] [36].

4 Empirical Results

The cross-section dependence test is the first data check test for analytical purposes and processing specific econometric methodology. As the name of this test mentioned, checking the cross-sectional independence of panel data is implied. The results of the residuals CD are presented in Table 2, which is evidence of positive significance at the 1% level in Breusch-Pagan LM, Pesaran Scaled LM, and Pesaran CD tests. The significance of the cross-section dependence tests declares the presence of cross-sectional dependency in selected data series [37-39].

Table 2

Residuals Cross-Section Dependency Test

CSD Tests	Pesaran's test	Probability
Breusch-Pagan LM Test	2231.54*	0.000
Pesaran Scaled LM Test	104.729*	0.000
Pesaran CD Test	12.942*	0.000

*Note: * is presenting a 1% level of significance.*

The results of four divergent panel unit root tests (PURTs) are presented in Table 2. The compilation of results is based on the integration level $Z_{it} \sim I(0) \, or \, Z_{it} \sim I(1)$ of data series for an individual intercept at the level and first difference [37]. The total greenhouse gases (TGE) are significant 1% level under four PURTs and integrated at first difference. The integration of urban development is confirmed at 1% under the first difference, while 2 (PP & LLC) methods supported level integration at 1% and 5%. The crop production index is significant at 1% under the first difference, while Phillip Perron of level-integration also shows significance at 1%. The economic development and land utilization are integrated at first difference under 4-panel unit-root tests at a 1% significance level.

Table 3

The Unit Root Test based on Individual Intercept Variables

Variables	Level				First Difference			
	ADF	PP	LLC	IPS	ADF	PP	LLC	IPS
TGE	34.314	41.211	-1.069	2.647	164.945*	301.618*	-6.844*	-9.309*
	0.723	0.417	0.142	0.996	0.000	0.000	0.000	0.000
LU	50.167	66.938*	-0.957	-0.964	273.415*	452.297*	-12.157*	-15.146*
	0.130	0.005	0.169	0.168	0.000	0.000	0.000	0.000
UD	44.167	219.202*	-3.103*	0.681	62.211**	52.843***	-3.683*	-2.135**
	0.300	0.000	0.001	0.752	0.014	0.084	0.000	0.016
ED	30.422	21.384	-2.952*	0.448	186.091*	240.314*	-11.090*	-10.646*
	0.863	0.993	0.002	0.673	0.000	0.000	0.000	0.000
AL	30.111	80.273*	-1.293***	2.012	173.056*	292.646*	-10.807*	-11.013*
	0.872	0.000	0.098	0.978	0.000	0.000	0.000	0.000

*Note: *, ** is presenting 1% and 5% level of significance.*

The Kao Engle–Granger-based cointegration test is significant at a 1% level. As per the Kao Engle-Granger based cointegration test, the outputs are acquired in five consecutive statistics named modified Dickey-Fuller, Dickey-Fuller, augmented Dickey-Fuller, unadjusted Dickey-Fuller, and unadjusted modified Dickey-Fuller. The significance of all five at the 1% level authorized the cointegration relation among variables. The collective results of cointegration tests are inveterate that total greenhouse gases (TGE), land utilization (LU), urban development (UD), economic development (ED), and agricultural land (AL) are moving toward a long-run equilibrium relationship altogether.

Table 4
Kao Engle–Granger-Based Cointegration Test

Tests	**Statistic**	**p-value**
Modified Dickey-Fuller	3.200*	0.001
Dickey-Fuller	3.966*	0.000
Augmented Dickey-Fuller	4.058*	0.000
Unadjusted modified Dickey-Fuller	3.103*	0.001
Unadjusted Dickey-Fuller	3.791*	0.000

*Note: *, ** is presenting 1% and 5% level of significance.*

The FMOLS is employed to determine the long-run elasticity of the panel. Table 5 consists of the results of FMOLS which confirmed the significance of the complete set of variables (LU, UD, ED & AL) at a 1% level. Land utilization shows a negative significance, while the rest of the four variables are positively significant. The FMOLS tackles simultaneity bias, non-exogeneity, and serial correlation problems. It obtains asymptotically efficient consistent estimates in data series [7] [14]. The cinematography of FMOLS results declares variables' positive or negative contribution to greenhouse gas emissions. The increase in land utilization with a percentage of -0.185 can decrease by 1% greenhouse gas emissions. The negative sign of the land utilization coefficient is an indication of a reduction in greenhouse gas emissions. In contrast, the positive sign of UD, ED, and AL confirm the positive contribution or enhancing behavior toward greenhouse gas emission. The negative contribution of land utilization is logical and considerable because the land is involved in both kinds of projections, i.e., environmentally friendly or unfriendly. An increase in UD 0.799%, ED 0.071% and AL 0.263% contributes a 1% increase in GHG individually. The positive and significant behavior of variables is the vibrant signal of positive contribution to greenhouse gases emission. The contribution of variables can be categorized as per their contribution [37] [40]. The DOLS is generally used to robust check the small sample, cross-check Ordinary Least Square (OLS) & the Fully Modified Ordinary Least Square (FMOLS), and control endogeneity biases. Table 5 also contained the results of DOLS in the last three columns [8]. The DOLS test's results present the increasing effect of independent variables and their impact on greenhouse gas emissions. The results of DOLS confirmed the significance of all variables except land utilization. Urban development and economic development are positively significant at 10% and 1% orderly, assuring their role in increasing greenhouse gas emissions. The agricultural land is negatively significant at the 5% level. Thus, the economic development contribution to greenhouse gases emission is comparatively low [7] [8].

Table 5

The Estimated FMOLS and DOLS

Regressors	Fully Modified OLS			Dynamic OLS		
	Coefficient	**t-Statistic**	**Prob.**	**Coefficient**	**t-Statistic**	**Prob.**
LU	-0.185*	-10.098	0.000	0.130	1.649	0.101
UD	0.799*	674.510	0.000	0.487***	1.925	0.056
ED	0.071*	7.952	0.000	0.246*	6.522	0.000
AL	0.263*	98.683	0.000	-2.019**	-2.061	0.040

*Note: *,**,*** is presenting 1% ,5% and 10% level of significance*

The confirmation of cointegration among variables is completed by the fundamental assumption to run VECM. The VECM results are displayed in table 6, and asterisks are placed on the top of coefficients to declare their significant levels. The causal relationship among variables is determined by applying VECM, which is presented in Figure 3. All variables' error correction term is significant, confirming a long-run relationship among the selected set of variables. Total greenhouse gases emission, urban development, and crop production index are significant and negative, while the rest of the two variables (LU & ED) are positively significant [7]. The ECt-1 term is positive and significant for TGE, ED, and AL at 1%, 1% & 10% orderly, while LU and UD are positively insignificant. All variables' short-run casual relationships are determined first and second to check the accurate and precise directional connection. The total greenhouse gas emission has a positive and unidirectional relationship with urban growth, $TGE \rightarrow UD$ at 1% level. Land utilization and agricultural land both are negatively significant at 5% and showing a unidirectional relationship with TGE as $LU \rightarrow TGE$ & $AL \rightarrow TGE$. Instead of a relationship directory of dependent and independent variables, the independent variables also show their association with their counterparts [19][40], as land utilization and economic development, are negatively related to each other $LU \rightarrow ED$ at 5% level. Economic development and agricultural land are negatively and bi-directionally related to each other, at a 1% level of significance$ED \rightarrow AL$. Agricultural land has confirmed the negative and significant unidirectional relationship between land utilization and urban development at a 10% level as $AL \rightarrow LU$ &$AL \rightarrow UD$. Agricultural land indeed broadened due to the expansion of economic development [41]. The metropolitan areas are generally developed regions due to more luxurious facilities that directly relate to energy consumption.

Table 6

Estimation of VECM Granger Causality

Dependent Variables	D (TGE)	D(LU)	D(UD)	D(ED)	D(AL)
EC_{t-1}	0.005*	0.003	0.000	0.017*	0.001***
D(TGE(-1))	0.030	0.046	-0.001	0.023	-0.025
D(TGE(-2))	0.072	-0.028	0.010*	0.108	-0.015

D(LU (-1))	-0.045**	-0.182*	0.000	-0.189**	-0.012
D(LU (-2))	-0.024	-0.126*	-0.002	-0.183**	-0.007
D(UD(-1))	0.591	-0.433	0.906*	0.124	-0.165
D(UD(-2))	0.251	-0.122	0.035	-0.970	0.348
D(ED(-1))	0.005	0.013	0.001	0.161*	-0.003*
D(ED(-2))	-0.017	-0.016	0.000	-0.079***	0.000
D(AL(-1))	0.032	-0.164	0.005**	0.100	0.071
D(AL(-2))	-0.279**	-0.447***	-0.012***	-0.464*	0.146*

*Note: *,**,*** is presenting 1% , 5% and 10% level of significance.*

The instantaneous results of VECM are presented in Table 7. The variables with the derivative sign display Granger causality in short-run effects. The last value with the caption "All" represents the ECT term, which confirmed Granger causality in the long run [19]. Urban development and agricultural land are significant at 1% and 5%, while the positive insignificance of land utilization and economic development is observed. The individual results of land utilization and economic development are positively insignificant, while all chi square pooled results are significant, at a 1% level.

Table 7
VEC Granger Causality/Block Exogeneity Wald Tests

Excluded	Chi-sq	df	Prob.
D(LU)	6.040	2	0.049
D(UD)	18.387*	2	0.000
D(ED)	2.145	2	0.342
D(AL)	6.621**	2	0.037
All	32.600*	8	0.000

*Note: *,**, *** is presenting 1%, 5% and 10% level of significance orderly.*

5 Discussion of Findings

This research confirmed that the G20 countries attributed divergent challenges to green technological development, environmental efficiency, and sufficient environmental administration in individual member countries. Land utilization and agricultural land utilize less than average techniques that deteriorate the balances and environmentally friendly development. The G20 countries should boost up their managerial sufficiency and technology advancement by introducing dual-wheel driving [8]. The results of this study have exposed remarkable changes in environmental sustainability regarding land utilization of G-20 countries from 1990 to 2019. The results of this research masterpiece revealed the long-run relationship among selected variables by employing the Kao cointegration technique [42] [43].

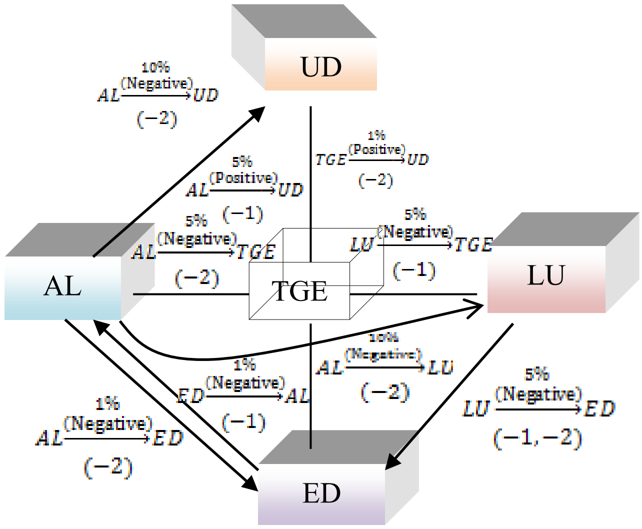

Figure-3
Causal Relationship among Variables

The results of the Granger Causality test have declared that UD and AL are the cause of environmental degradation and authorize their contribution with positive significance. The directional relationship among variables confirmed a positive unidirectional relationship between total greenhouse gases (TGE), with urban development (UD) and a negative unidirectional relationship between land utilization (LU) and agricultural land (AL). Urban development becomes the reason for many toxic emissions, land erosion, and disturbance of ecology conservation Halton. In contrast, land utilization or agricultural land is less toxic but more environmentally friendly. There are two key reasons to suspect that the GHG emission figures reported in this research have been calculated conservatively. First, it should be remembered that increasing urban development in degraded cereal-producing areas was thought to increase carbon emissions [1] [14].

This is because more transportation and fuel-burning emissions result from the rapid growth and development of the metropolitan regions [22] [23]. Second, land use is more vulnerable to fire due to ecological degradation and most land cover changes. As a result, GHG emissions caused by fire are inextricably related to environmental damage. These emissions, however, were not included in this study [2] [20] [44]. The individual governments of the G20 countries should implement the policies of laypeople and agencies to put an eye on the good practices of environmental protection. The developing and emerging members of the G20 should focus more on ecologically friendly growth projects.

Concluding Remarks and Implications

This research is conducted to determine the dynamic relationship between total greenhouse gases, land utilization, urban development, economic development and agricultural land by employing FMOLS, DOLS and VECM. The analysis process initiated by checking the cross-dependency and integration level of the data series i.e., at the level $Z_{it} \sim I(0)$ and first difference $Z_{it} \sim I(1)$. The results of the integration check revealed that cointegration is feasible to be applied. The Kao cointegration, FMOLS, and DOLS tests are employed to determine the long-run relationship among variables, while the VECM explores the directional relationship and speed of adjustment from the short to long-run period. Greenhouse gas emissions of the G20 countries were mainly caused by urban development, economic development, and agricultural land, while land utilization reduced greenhouse gas emissions. Technical products and heterogeneity of G20 nations are evident in greenhouse gases emission. The occupation of the global map by G20 countries is recognized as leading countries, so they have more room for environment quality optimization.

The green technology promotion in the production and consumption of energy can work more quickly because this research is indicated that the urban development sector is neglected more. All countries' research and development sectors should promote clean technology for all sectors of the economy to minimize greenhouse gas emissions. This is a more concerning part of the implication when countries will introduce clean technology simultaneously.

In future research work, different countries or groups of countries, can be explored, as well as expanding the discussion of environmental sustainability. In future research, the study can be divided into three leading groups of countries, as catching-up countries (chasers), leading countries (technology leaders) and best practice countries (best practitioners).

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