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Abstract:

Increasing agricultural land use is required to achieve SDG1 (no poverty) and SDG2 (zero hunger). However, agricultural land use and other input intensification strategies have been questioned due to the danger of increasing emissions of greenhouse gases (GHG) and damaging natural capital.

Most contemporary approaches to agricultural land management and its consequences on the GHG are mostly discussed from the classical economic perspectives. Though the nature of institutions plays a pivotal role in resource allocation of any society and impact, the failure of micro and macroeconomic policies could not be explained by the old institutionalism. Adverse effects of GHG and land use become external to the market and the market may be failed to capture actual cost and benefits. New Institutional Economics (NIE) attempts to prevent market externalities by introducing transaction costs to contractual arrangements and the legal system, stressing the importance of institutions or governance in minimizing and avoiding market failure by lowering transaction costs.

We found that the influence of governance on agricultural land use management and GHG emissions is not comprehensively researched with scientific data. This research contributes to the existing knowledge by quantifying the effects of institutions measured by governance indicators on agricultural land use and GHG emission using a panel dataset covering 176 countries for the period 2002-2019. A Two-Stage Least Square (2SLS) estimation technique was utilised to quantify the impact. The moderating influence of the overall governance on agricultural land use has decreased the GHG emission by 2 per cent. Moreover, individual governance indicators, control of corruption (COC), regulatory quality (RGQ), voice and accountability (VAC), and absence of violence/terrorism (POS) have a significant moderating influence on agricultural land usage by 7 per cent, 6 per cent, 9 per cent, and 33 per cent, respectively. The research findings provide empirical confirmation backing and verifying that the quality of institutions measured by the World Bank governance indicators enhances sustainability by changing agricultural land use and reducing GHG emissions.

Keywords: Greenhouse gas emissions, governance, institutions, and agricultural land use
JEL Classification: H11, Q5, Q24, Q28, Q56, and O11

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1. Introduction

While increasing agricultural land use and intensification of other farm inputs are required to achieve SDG1 (no poverty) and SDG2 (zero hunger), the farming community must not ignore the emissions of greenhouse gases (GHG) which affect SDG11 (sustainable cities and communities) and SDG13 (climate action). SGD1 and SDG 2 are strongly related to economic growth or output growth which links to SDG8 on Decent work and economic growth and SDG 12 on responsible consumption and production. SDG8 and SDG12 depend on productivity, technology and inputs or resource endowment, also known as physical capital, human capital, natural capital, and labour (Gordon, 2012; Jones & Romer, 2010; Mankiw, Romer, & Weil, 1992; Solow, 1956). Agricultural land use and other input intensification strategies have been questioned due to the danger of damaging natural capital, which includes environmental assets, ecosystem services, ecosystems, biodiversity, and natural resources (Greenstone, 2014). And therefore, Sustainable Agriculture Intensification (SAI) has been identified as one of the approaches to achieve those targets by mitigating the damage.

Moreover, SAI has been a crucial solution to promoting human development, ensuring sustainable food security, and meeting current food needs (Dawson, Martin, & Camfield, 2019; Pretty & Bharucha, 2018). The United Nations Food and Agriculture Organisation (2011, p. 102) has defined SAI as "to produce more products from the same region while saving resources, reducing negative impacts on the environment, enhancing natural capital and ecosystem services flow." Moreover, governance and agricultural land use are emerging issues of public policy debates as they have enormous environmental impacts on natural capital, SDG13, and SAI.

According to OECD (2017) land utilisation is connected to about one third of all human-generated CO_2 emissions. Meanwhile, 174 countries signed the Paris Climate Agreement in 2016, promising to cut CO_2 emissions to constrain global warming below 2 degrees Celsius over pre-industrial stages. To decrease global temperature increase successfully, GHG emissions must be cut down by a higher rate than achieved in the past (Llorca et al., 2020). The SAI encourages increased yield with the least negative environmental impact without converting more non-agricultural lands. Therefore, achieving SDG1 and SDG2 through SAI while reducing GHG is a real challenge (Sharma, Kaushal, Kaushik, & Ramakrishna, 2021).

In addition to many other factors, a country's land use management and emissions of GHG depend on its governance. It is crucial to know how governance can help realise sustainable development. Since the publication of the World Commission on Environment and Development: Our Common Future and other significant works, one can identify the close association between sustainable development and governance (Brundtland, 1987; Güney, 2017; OECD, 2017).

Most contemporary approaches to agricultural land management and its consequences on the GHG are primarily examined from the classical economic perspectives. Though the nature of institutions plays a pivotal role in the allocation of resources in any country and its impact, the failure of micro and macroeconomic policies could not be explained by the old institutionalism (Joskow, 1987, 2008). Adverse effects of GHG and land use become external to the market and the market may be failed to capture the actual cost and benefits. New Institutional Economics (NIE) attempts to prevent market externalities with its fundamental concepts. Coase (1960) and North (1990) introduce the costs of the transaction to contractual arrangements. Moreover, a legal system must be established to enhance the capacity to claim performance. Whinston (2003) argues that property rights and transaction costs are essential for any social contract. Furthermore, Rodrik (2008) and Whinston (2003) stress the importance of institutions in minimizing and avoiding market failure by lowering transaction costs.

Researchers, policy makers, and international organisations consider good governance crucial for sustainable economic development (Acemoglu, 1998; Acemoglu & Robinson, 2019; Güney, 2017). In 1993, the UN Statistical Commission introduced the System of Environmental-Economic Accounting (SEEA) as a satellite system to compile and represent data related to the economics of the environment. Natural capital has renewed consideration from established researchers, academics and policymakers in further encouraging sustainability (UN Environment World Conservation Monitoring Centre (UNEP-WCMC), 2019). Since the introduction of SEEA, many researchers have examined the value of natural capital, considering numerous kinds of the ecosystem and natural capital (Collados & Duane, 1999; Saito et al., 2019; Shoyama et al., 2019).

Our literature review, however, suggests that the impact of governance on agricultural land use management and GHG emissions are not comprehensively researched with scientific data. Understanding how governance influences land use management and how it links to the emission of GHG is critical for policymakers concerned about the inappropriate use of land in achieving food security since strategies to mitigate CO2 through forestry activities also are given greater attention (Law et al., 2008). The current research contributes to the literature by quantifying the influence of governance on agricultural land use and the emission of GHG.

The current research is structured as follows. Section two provides a survey of the available literature, section three furnishes a conceptual framework, and section four explains data and methodology. Section five delivers the analysis of results, and section six concludes with remarks and findings.

2. Review of literature

This literature survey has two objectives. The first is systematically studying sub-themes pertaining to governance, land use, and GHG emission. The second objective is identifying literature gaps in the link between land use, governance, and GHG. This will enable our study to identify problems and address the literature gaps correctly.

SAI has been a crucial solution to promoting human development, ensuring sustainable food security, and meeting current food needs (Charles, Nzunda, & Munishi, 2014; Dawson et al., 2019; Godfray et al., 2010; Godfray & Tara, 2014). Many studies have focussed on land use and productivity. According to a report of the Asian Productivity Organisation (2003), most Asian countries cannot increase land cultivation area, and policy makers are pursuing means to intensify the production process to raise the income of the farming community on prevailing land. Improving land and other resource utilisations is vital to address this problem. This report using eleven country cases suggests that scientific knowledge and various methodologies conserve land while improving productivity.

Hunger and income poverty can be illuminated by increasing income which depends on economic growth. He et al. (2014) found a change in land utilisation patterns in China, shifting cultivated agricultural land into town, industrial areas, and transportation sectors. This change occurred due to economic growth, as shown by a significant correlation between the evolution of land utilisation and GDP. This author argues that land use affects economic growth in four different ways: (1) Land use enhances agricultural production and manufacturing industries and services; (2) Land development improves natural capital accumulation; (3) Land is often employed as leverage to attract FDI; and (4) Local governments act purposefully in providing land for non-agricultural usages. Jin et al. (2018) investigated the effect of land use on China's economic growth. Their paper used an econometric model to discover the impact of land input on the economic progress of Chinese municipalities at the various phases of development. According to Jin et al. (2018, p. 13) , "the development of 352 cities and regions in China in 2015 can be divided into five stages; namely, primary production stage (PPS), primary industrialization stage (PIS), middle industrialization stage (MIS), later industrialization stage (LIS), and developed stage (DS)." Based on their econometric analysis, the land utilisation of municipalities and regions at PPS, PIS, and MIS considerably enhanced output.

2.1 Agricultural land use and GHG emissions

According to OECD (2017) land utilisation has been connected to about one third of all manufactured CO_2 emissions since 1850. Land use also impacts air pollution, cities' living conditions, and public health. Beach, Zhang, and McCarl (2012) assessed the deviations in land utilisation patterns in the U.S. due to biofuel and climate action policies and the impact of those policies on greenhouse gas (GHG) emissions under different technological assumptions. The period of study covered the data from 2007 to 2022. This shows that the decrease in GHG emissions due to the Renewable Fuel Standard (RFS) is about 2 per cent. However, these GHG savings can be negated by emissions due to unintended changes in land utilisation. Bokhari et al. (2022) assessed the spatial variations in the land utilisation in planned Islamabad and semi-planned city of Rawalpindi urban areas from 1976 to 2016. The authors concluded that changes in land use affect the structure, performance, and capabilities of natural ecosystems.

Japan is the first non-Western and first Asian country to achieve high economic growth and development. Despite its rapid growth and development, the country preserved its natural capital, including a forest coverage above 60%, providing a classic example of other countries' land use practices. Many studies use various methods regarding natural capital (including lands) estimates in Japan (Kumagai et al., 2021). They examined the values of land and maritime natural capital utilising internet surveys and payment card methods. Saito et al. (2019) did a national level scenario analysis relating to natural capital, while Shoyama et al. (2019) did a land scenario analysis using vegetation inventories in Japan. Natuhara (2013) studied ecosystem services by taking paddy land as a natural wetland.

Meanwhile, in 2012, the Office for National Statistics (ONS) in the UK published a comprehensive framework of accounting for the value of nature, which can be used as a bench-mark for land use management in other countries. The road map highlighted strategies to integrate natural capital into UK Environmental Accounts by 2020. Natural Capital Committee (2014) developed a Framework for Measuring and Defining changes in Natural Capital in the UK. Since then, there have been many advances in quantifying natural capital (Lusardi, Rice, Waters, & Craven, 2020). Sri Lanka is known for its beauty and rich biodiversity, representing a classic case study for developing countries. However, many environmentalists are worried about activities damaging the natural environment and lack accurate data on natural capital. Some studies deal with climate variation's influence on home gardens (Marambe, Silva, Nowak, & Weerahewa, 2016; Weerahewa, Pushpakumara, Silva, & Daulagala, 2012).

2.2 Governance and agricultural land use

According to FAO and UNEP (1997, p. 14), the most severe problem in resource management is institutions rather than technical. Acemoglu and Johnson (2005) attempt to unbundle the wide-ranging cluster of institutions and learn the comparative significance of contracting and property rights institutions at the macro level. Some argue that costs in resolving land use are huge due to a lack of property rights. Feiock (2004) investigated the factors affecting second-generation land utilisation boundaries generated from inclusive or comprehensive preparation. The author found that political institutions are associated with administration policies prescribed by distributive principles of urban politics. The author analyses the impact of various factors affecting land use in the fiscal year 1997/98, taking data from 34 Florida counties (in the US) and applying Tobit maximum likelihood estimation techniques. The results show that local actors' political incentives influence second-generation land-use regulation.

Koroso et al. (2019) and Newell & Taylor (2018) study how the change in institutional arrangements affects better land tenure security provision. According to the authors, it is unclear if the transformation in land related establishments yields the expected result in the non-existence of reliable corresponding establishments such as political and legal systems. This study analysed ten country cases to discover a strong link between land connected institutions' reliability and the quality of political and legal institutions that affect land tenure. The result shows a strong association between the quality of political and legal institutions and land-related institutions. Based on the findings, the authors argue that it is essential to put efficient political and legal establishments in place to create a credible land institution. Many other papers discuss various factors affecting land use in China; for details, see (Fan, Zheng, & Shi, 2016; Zhou, Zhao, & Zhou, 2017).

The bioeconomy is an emerging concept that provides many chances to address social concerns and must be embraced to achieve the SDGs and improve citizen wellbeing (Barañano, Garbisu, Alkorta, Araujo, & Garbisu, 2021; Costanza et al., 2017; Costanza et al., 2014; Stegmann, Londo, & Junginger, 2020; Taffuri, Sciullo, Diemer, & Nedelciu, 2021; Wesseler & Braun, 2017). For instance, recent confirmation that the bioeconomy is a top political priority in Europe comes from the EU's 2018 Bioeconomy Strategy Update and the European Green Deal (Kardung et al., 2021). Kardung et al. (2021) proposed a conceptual framework for measuring and analyzing the growth of the EU bioeconomy. The authors suggested new metrics for assessing the effects of shifting supply and demand factors, availability of resources, and policies on sustainability goals, including agricultural land utilisation and greenhouse gas emissions.

Sajid and Danial (2021) outline the historical significance of institutions in fostering the long-term growth of the biofuel industry in Brazil and the USA. Additionally, it gives a general summary of how institutional decisions affect the economy. The study finds that the U.S. and Brazil's bioeconomies have benefited from systematic legislation and solid and long-term renewable energy policies. Peerzada et al. (2021) adopt a bioresource perspective to investigate obstacles and chances for Jammu and Kashmir's transition to a sustainable bioeconomy (J&K). Local communities in J&K's forests extract a wide variety of priceless non-timber forest products (NTFP) for their sustenance and income. The authors show that, with the proper steps, including NTFP, local communities' earnings might rise by 18 times their present value. However, to fully realize this potential, institutional models with inclusive policies and governance frameworks based on expanded access and benefit sharing would enable the transformation of the local economies into bioeconomies. These studies mentioned above examined the impact of institutions based on small regions and products, and an assessment of institutional implications at the global level is absent.

The above literature survey shows that many papers discuss factors determining land utilisation patterns and how land utilisation patterns affect the GHG. In the literature, we could not find the quantification of the effects of institutions on land utilisation and GHG emission. Therefore, the current paper attempts to investigate the impact of governance on agricultural land utilisation and GHG through the conceptual framework developed in the next section.

3. Conceptual framework

The proposed conceptual framework (Figure1) contributes to the literature by clearly illustrating how governance is responsible for land utilisation and the emission of GHG. We investigate the details of how governance affects GHG and the natural capital given by Global Reporting Initiatives (UN Environment World Conservation Monitoring Centre (UNEP-WCMC), 2019) (Greenstone, 2014). First, governance affects the two major human activities, i.e., consumption and production (SDG 12), through input to achieve SDG8 (decent work and economic growth). These inputs include technology, natural capital, human capital, physical capital, and labour (Gordon, 2012; Solow, 1956). Agricultural land is a critical element of natural capital which is one of the most significant elements of wealth in low-income economies (47 per cent in 2014) and more than 25% of the wealth in lower-middle-income economies (Lange, Wodon, & Carey, 2018).

Using agricultural land and intensifying other agricultural inputs have undergone modernisation, e.g., "novel cultivation packages, double cropping, improved seeds, fertilisers and pesticides, mechanisation, and institutional arrangements" (Marambe, Jayawardena, Weerakoon, & Wijewardena, 2020, p. 225). These transformations significantly impact natural capital, including environmental assets, ecosystem services, ecosystems, biodiversity, and natural resources (Greenstone, 2014). GHG emission and natural capital have two-way causation according to our framework.

According to Acemoglu et al. (2005), Acemoglu & Robinson (2013) and Acemoglu et al. (2019) governance or institutions affect resource allocation for inputs, which indirectly impacts GHG through SDG8 and SDG12. The authors highlight extractive and inclusive political, economic and social institutions. Good governance supports inclusive political and economic institutions. According to OECD (2017), governance of land use is essential because land and the buildings of six OCED countries constitute 86% of the total capital in the OECD and have a value of nearly USD 249 trillion. In the analysis, we have created one composite index of governance (INS) using six key dimensions, namely (1) Voice & Accountability, (2) Political Stability and Lack of Violence, (3) Government Effectiveness, (4) Regulatory Quality, (5) Rule of Law, and (6) Control of Corruption developed by (Kaufmann, Kraay, & Zoido-Lobatón, 1999) to quantify the direct impact on GHG (Figure 1). The impact of institutions (INS) is captured in the proposed equation two below.

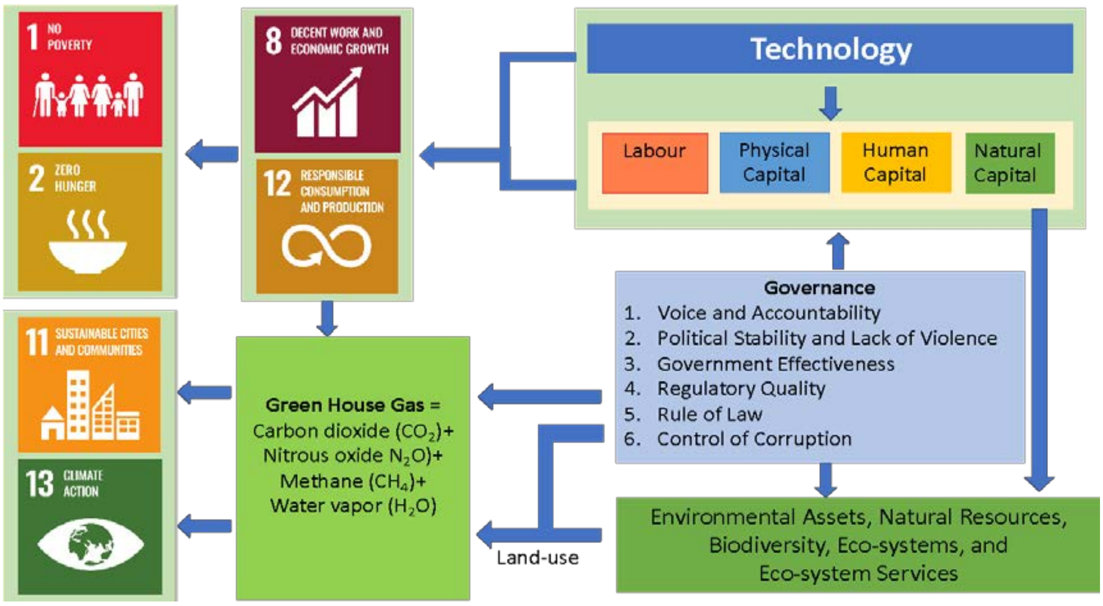

Figure 1. The conceptual framework for understanding the nexus of how governance affects agricultural land use and GHG emission.

4. Data and methodology

4.1. Data

The analysis of this paper utilised a panel dataset covering 176 countries from 2002 to 2019. The dependent variable, GHG emission variable, was created using the CO_2 emission, CO_2 equivalent emission from CH_4, and CO_2 equivalent emission of NO_2 gathered from the FAO database[2]. The institution, the independent variable of this study, was captured using worldwide governance indicators (WGIs). The six WGIs were used to create a composite governance index (INS), which included political stability and absence of violence/terrorism (POS), government effectiveness (GEF), voice and accountability (VAC), the rule of law (ROL), regulatory quality (RGQ), and control of corruption (COC). The variable INS is endogenous in our model because this variable is created using governance indicators. According to Globerman and Shapiro (2002), governance indicators are superior to other factors used elsewhere since these indicators are estimated, including 31 different qualitative indicators from 13 reliable sources. The composite governance index was created using principal component analysis (PCA) since the meta-indices in governance measures are highly correlated with each other and aggregate measures using principal components would represent institutional excellence (Emara & Chiu, 2016; Globerman & Shapiro, 2002). The FAOSTAT was then used to obtain the other primary independent variable, agricultural land use (AGLAND).

As for controls variables data, countries' total population (POP), per capita GDP (GDPPC), and access to electricity by households (ELECT) were collected from the world development database. This study employed the instrumental variables found in the prior studies on governance and CO_2 emission. Accordingly, as the instrumental variables, the classification of legal origin, measures of ethnolinguistic fractionalization and latitude, which measures the distance from the equator, were used based on the research by La Porta et al. (1999), Guney (2017) and (1995).

[2] The main elements of Green House Gas include Carbon dioxide (CO_2), Nitrous oxide N_2O), Methane (CH_4), and Water vapour (H_2O).

4.2. Specification of Model and Model Estimation Techniques

4.2.1. Principal Component Analysis (PCA):

PCA was utilised to develop a composite governance index to capture institutions' qualities (Kaufmann et al., 1999). PCA employs the orthogonal transformation to transform a series of sample observations of probably connected variables ($X_1 \ldots X_P$) into a set of linearly uncorrelated variables ($PC_1 \ldots . PC_K$), which are referred to as principal components. The authors look for a considerably fewer number of principal components to extract evidence from the original set of X variables as possible. This process consists of three steps: creating a correlation matrix, extracting factor loading, and calculating commonalities (Nayak, 2020). The projected model is shown below:

$$INS_{it} = (PC_{VA} \times VA_{it}) + (PC_{PS} \times PS_{it}) + (PC_{GE} \times GE_{it}) + (PC_{RQ} \times RQ_{it}) + (PC_{RL} \times RL_{it}) + (PC_{CC} \times CC_{it}) \quad (1)$$

4.2.2. Two-Stage Least Squares (2SLS) method:

The two-stage least squares (2SLS) regression analysis was employed with selected instrumental variables to assess the impact of institutions and agricultural land use on CO2 emission. Econometricians use 2SLS to estimate linear simultaneous equations system parameters and solve the omitted-variables bias in the single-equation model (Angrist & Imbens, 1995). The representation of the model adopted in this study is as follows:

$$GHG_{it} = \alpha_1 AGLAND_{it} + \alpha_2 INS_{it} + \alpha_3 (AGLAND \times INS)_{it} + \alpha_4 POP_{it} + \alpha_5 GDPPC_{it} + \alpha_6 ELECT_{it} + \varepsilon_{it}, \quad (2)$$

The subscripts i and t refer to cross-section units and periods, respectively. GHG_{it} indicates the carbon dioxide emission, INS_{it} denotes the composite governance index, $AGLAND_{it}$ is the countries' agricultural land use while, $AGLAND \times INS_{it}$ implies the interaction term of the institutions with the agricultural land use, which captures the effect of institutions on agricultural land usage. $PCGDP_{it}$, POP_{it} and $ELECT_{it}$ are the structural controls denoting per capita gross domestic product, countries' total population, and access to electricity, α_1 to α_6 are the respective coefficients to be estimated and ε_{it} shows the error term. Using the 2SLS estimation technique in estimating the model cited above helped overcome the possible omitted-variables biases and provided reliable estimates of the structural parameters (Angrist & Imbens, 1995).

Numerous diagnostic assessments were used to decide if the proposed model sufficiently captured the relations between the variables. Under-identification is a Lagrange multiplier (LM) test that examines if an equation is identified and if the excluded instruments are linked with the endogenous regressors. The LM variant of Anderson's canonical correlation test is used to determine whether or not an equation has been identified. The Cragg–Donald F-test was used to test the null hypothesis of weak instruments (Stock & M., 2005). According to the article, an instrument is regarded as "very strong" if the Cragg–Donald F-statistic is greater than 10% of the maximum IV size. It is categorised as "strong," "medium," or "weak" if the maximum IV size is between 10% and 15%, 15% to 20%, or 20% to 25% of the total. The validity test (overidentified restrictions) identifies the instrument's weakness using the error term. The Sargent test was done to decide the validity of this analysis. It is hypothesised that all instrumental variables in stage two regression were not correlated with the error term, and the non-significance judgment verified the null hypothesis. The endogeneity test determined if the endogenous regressors utilised were truly exogenous. The significance level ($p \leq 0.05$) was used to discard the null hypothesis of no endogeneity.

5. Analysis and Discussion of Results

Table 4.1 contains the summary statistics of the sample. The GHG emission ranged from -6.438 to 13.873 kilotons in natural log form. The agricultural land use of an average country in the sample was 8199ha in natural log form. Based on the minimum and maximum estimates, the composite governance index (INS) ranged between -5.824 and 5.181.

Table 4. 1: Summary of Descriptive Statistics.

Variable	Number of Observations	Mean	Standard deviation	Minimum	Maximum
GHG	3168	8.565	2.611	-6.438	13.873
AGLAND	3168	8.199	2.515	1.389	13.179
INS	3149	0	2.261	-5.824	5.181
POP	3142	15.096	1.991	9.193	19.97
GDPPC	3017	8.492	1.433	5.555	11.566
ELECT	3098	77.796	30.459	1.3	100

According to the results in table 2, GHG emission and AGLAND had a positive and significant association, whereas GHG emission and INS had a negative and significant correlation. Similarly, almost all structural controls considered in the study demonstrated significant correlations.

Table 4. 2: Correlation Matrix.

Variables	GHG	AGLAND D	INS	POP	GDPPC	ELECT
GHG	1.000					
AGLAND	0.821*	1.000				
INS	-0.120*	-0.304*	1.000			
POP	0.766*	0.766*	-0.097*	1.000		
GDPPC	-0.051*	-0.229*	0.811*	0.053*	1.000	
ELECT	0.009	-0.170*	0.523*	0.094*	0.771*	1.000

* *p<0.1*

Table 4. 3: Results on the Impact of agricultural land use and institutions on CO_2 emission.

Variables	(1) INS	(2) ROL	(3) COC	(4) GEF	(5) RGQ	(6) VAC	(7) POS
INS	0.3150**	0.5708**	0.8351**	0.6609*	0.7847**	0.9669**	3.2844***
	(2.0494)	(2.0030)	(2.1773)	(1.6825)	(2.1941)	(2.2469)	(3.4809)
AGLAND	0.5410***	0.5313***	0.5365***	0.5379***	0.5375***	0.5184***	0.6319***
	(29.4067)	(37.1111)	(32.9213)	(30.2725)	(33.0999)	(40.9829)	(16.9721)
AGLAND x INS	-0.0242*	-0.0396	-0.0711*	-0.0382	-0.0635*	-0.0889**	-0.332***
	(-1.6587)	(-1.4362)	(-1.8992)	(-1.0077)	(-1.8408)	(-2.0083)	(-3.5485)
POP	0.4011***	0.3966***	0.4022***	0.3741***	0.3758***	0.4352***	0.4349***

	(26.5584)	(26.3056)	(26.3296)	(20.2284)	(20.3465)	(19.9988)	(19.0217)
PCGDP	-0.0382	-0.0291	-0.0356	-0.0861	-0.0222	0.0246	-0.0798
	(-0.7103)	(-0.6527)	(-0.6469)	(-1.5256)	(-0.4592)	(0.7196)	(-1.0913)
ELECT	0.0042***	0.0043***	0.0048***	0.0042***	0.0038***	0.0032***	0.0047***
	(3.8861)	(4.1441)	(3.8944)	(3.8824)	(3.7641)	(3.3785)	(3.4445)
Constant	-1.8259***	-1.7184***	-1.8489***	-0.9364*	-1.4876***	-2.6071***	-2.9976***
	(-5.6472)	(-5.4106)	(-5.4523)	(-1.9310)	(-3.4004)	(-12.2305)	(-13.0199)
Observations	2,827	2,828	2,828	2,828	2,828	2,828	2,827
R-squared	0.8226	0.8255	0.8179	0.8281	0.8234	0.8084	0.7215
Anderson canon. Corr. LM	171.83	223.09	119.53	109.66	145.32	88.36	35.72
P- value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Crag-Donald Wald F	91.22	80.47	62.22	56.88	76.38	45.48	12.02
Max crit. val	(19.93)	(13.91)	(19.93)	(19.93)	(19.93)	(19.93)	(9.08)
Overidentification test	0.028	5.23	0.005	0.358	0.016	0.285	3.409
P- value	(0.867)	(0.073)	(0.942)	(0.549)	(0.894)	(0.596)	(0.182)

Note: All models are estimated using a 2SLS estimation. The numbers in parentheses are coefficient and t-statistics. ***, ** and * indicate significance at 1%, 5% and 10% levels respectively.

The results of the 2SLS estimation are reported in Table 4.3. Model 1 was estimated with a composite governance variable as the independent variable to represent the collective influence of institutions on GHG. Models 2–7 were calculated using specific governance variables as independent variables to investigate the relative impact of various elements of institutions on GHG emissions. Anderson canon. Corr. LM, the diagnostic test confirmed that fitted models were valid since the endogeneity test indicated endogenous variables (0.00 < 0.05). The Crag-Donald Wald F test for weak instruments verified that the instruments utilised in the model were not weak, as F values are more significant than the provided critical values for 10 per cent or 5 per cent. The overidentified limitations test revealed that p-values are more significant, fail to reject the null hypothesis and that instrumental variables are valid.

Governance and agricultural land use variables had a significant positive influence on GHG emission in all models, indicating that the sample's GHG emissions were significantly enhanced by the prevailing institutions and agricultural land use. As per the objectives, the moderating impact of the institutions on agricultural land use has decreased the GHG emissions, which implies the practical implications for governance on agricultural land use were effective towards reducing the human-made CO_2 emission. Results indicate that increasing one unit of institutions towards agricultural land use has decreased the GHG emission by 2 per cent. Furthermore, results on the individual and institutional impact indicate that the moderating effect of COC, RGQ, VAC, and POS on agricultural land use has decreased GHG emissions by 7 per cent, 6 per cent, 9 per cent and 33 per cent, respectively.

Furthermore, figure 4.1 depicts the institutional moderating impact of agricultural land use on GHG as incremental towards the negative environmental impact. Results show that decreasing the GHG emission when the institutional impact is focused on the efficient use of agricultural land sustainably. Such significant results lie between the 0 to -2 coefficients on overall INS and the separate governance indicators, as given in the figure.

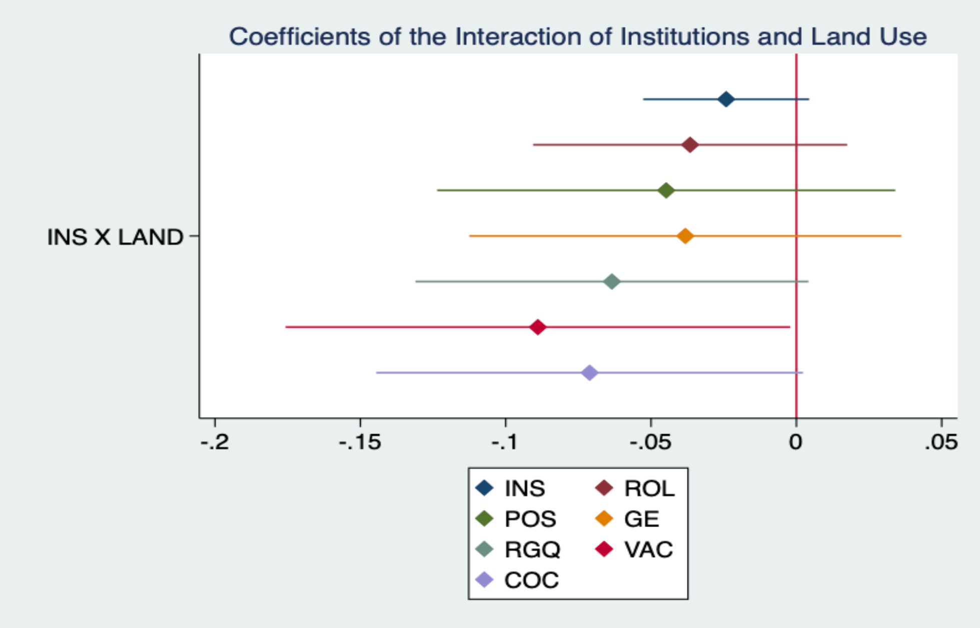

Figure 4. 1: Interaction of the Institutions and Agricultural Land Use

Note: See Appendix table 1 for details of variables.

Table 4. 4: Results on Impact of Agricultural land use and Institutions on GHG emission based on income category.

Variables	(1) L & LM	(2) H & UM
INS	0.5849***	-1.1404***
	(4.5294)	(-3.2829)
AGLAND	0.4480***	0.6402***
	(19.0965)	(15.6954)
AGLAND x INS	-0.0383***	0.1127***
	(-3.0297)	(3.1235)
POP	0.5274***	0.3143***
	(20.1439)	(11.6571)
PCGDP	-0.1893***	0.1380*
	(-3.5042)	(1.7115)
ELECT	0.0077***	0.0062***
	(3.8202)	(3.6424)
Constant	-2.1957***	-2.9165***
	(-5.4106)	(-3.4265)
Observations	714	875
R-squared	0.8534	0.6910
Anderson canon. Corr. LM	157.90	141.65
P- value		

	(0.000)	(0.000)
Crag-Donald Wald F	66.73	55.76
5% Max crit. val	(13.91)	(13.91)
Overidentification test	0.636	2.525
P- value	(0.728)	(0.283)

Note: All models are estimated using a 2SLS estimation. The numbers in parentheses are coefficient and t-statistics. ***, ** and * indicate significance at 1%, 5% and 10% levels respectively.

Then the results in the above table 4.4 indicate institutional and agricultural land use impact on GHG emissions based on the income categories of the countries. Countries in our sample were partitioned into two segments, where model 1 shows the low- and lower-middle-income countries' results and model 2 depicts the effects on upper-middle- and high-income countries. As per the results, 2SLS estimation indicates its specification tests to identify the models as consistent. A composite governance index was used to investigate the total influence of institutional quality on GHG models 1–2. Anderson canon Corr. LM, the diagnostic test proved that estimated models were accurate since the endogeneity test revealed endogenous variables (0.00 < 0.05). The Crag-Donald Wald F test for weak instruments revealed that the instruments utilised in the model were not weak since the findings of F values were larger than the provided critical values for 10% or 5%. The overidentified limitations test revealed that the instrumented variables were unrelated to the GHG error term (0.00 > 0.05).

Results in model 1 depict that both institutions and agricultural land use have increased the GHG in a significant manner. However, the interaction term of the good governance on agricultural land use has significantly discouraged the GHG among low and low-middle income countries since results indicate when one unit increased by the institution's moderation on agricultural land use, GHG has decreased by 3 per cent. Conversely, model 2 shows the higher and upper-middle-income country categories. According to the results, the impact of institutions on GHG emissions is negative and significant. In that scenario, results imply that one unit increase in good governance indicators has decreased the GHG emission by 114 per cent, which is a significantly high impact solely given by the institutions. However, the agricultural land use of such countries has increased GHG emissions. The moderating institutional effects on agricultural land use are positive and significant, implying the institutional focus on GHG via agricultural land use was ineffective.

6. Conclusion

We undertook a literature survey and found no comprehensive quantification of the effects of governance on agricultural land utilisation and GHG emission. Therefore, we attempted to quantify the impact of governance on agricultural land utilisation and GHG emissions using two econometric models. The study employed the two-stage least squares (2SLS) regression analysis with the sample of 176 countries selecting respective variables for the 2002-2017 period.

The regression results in both models confirmed that governance and agricultural land use had induced GHG emissions. Model 1 depicted, as we hypothesised, the moderating influence of the overall governance index on agricultural land use has decreased the GHG emission by 2 per cent in the sample countries. Furthermore, individual governance indicators

COC, RGQ, VAC, and POS have a significant moderating influence on agricultural land usage by 7 per cent, 6 per cent, 9 per cent, and 33 per cent, respectively.

Based on model 2, we conclude that moderating the impact of governance on agricultural land use discourages GHG emissions in low and lower-middle-income countries. The overall empirical evidence of the study support and verify that the quality of institutions measured by the World Bank governance indicators enhances sustainability. Our findings are supported by (Acemoglu, 2009; Acemoglu & Johnson, 2005; Acemoglu et al., 2005; Feiock, 2004; Güney, 2017; OECD, 2017). The policy implication of the study is that if developing countries can improve the quality of institutions, as measured by the governance indicators, they can change the agricultural land use patterns sustainably and reduce GHG emissions effectively. The market alone may not be adequate to reduce GHG emissions and must be accompanied by quality inclusive economic, political and social institutions.

Appendix table 1:

Variable	Measurement Variable	Source
Green House Gas (GHG)	(CO_2) carbon dioxide emission data; CO_2 equal to methane (CH_4) and nitrous oxide (N2O)	Food and Agriculture Organization of United Nations (FAO) (2022)
Agriculture Land (AGLAND)	Agricultural land used for temporary crops, permanent crops, and protective cover	
Population (POP)	Countries' total population	World Development Indicators, World Bank (2022)
Per Capita GDP (GDPPC)	Per capita gross domestic product	
Access to electricity by household (ELECT)	Electricity access by the household	
Good governance composite index (Institutions) - INS		
Voice and accountability (VAC) Political stability and absence of violence/terrorism (POS) Government effectiveness (GEF) Regulatory quality (RGQ) The rule of law (ROL) Control of corruption (COC)		Kaufmann, Kraay. & Zoido-lobatón (1999), and World Governance Indicators, World Bank (2022)

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