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The impact of eco-innovation, remediation liabilities of government, and sustainable environmental on soil pollution in China

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ABSTRACT

Traditionally, laws regarding soil pollution were limited in China. However, due to rapid industrialization and urbanization, soil pollution has become a major environmental issue. Thereby, in order to address the emerging threat, different measures have been introduced and implemented by Chinese government. The paper, in this regard, examines the role of government measures to reduce soil pollution, eco-innovation, and environmental sustainability on soil pollution in China. secondary data from the World Development Indicators (WDI), Chinese Soil Database, the global economy, and the environmental performance index (EPI) has been collected from 1985 to 2020. Autoregressive distributed lag model is used in the study to check the relationship among constructs. Findings reveal that government expenditures to reduce soil pollution, eco-innovation, and environmental sustainability have a negative association with soil pollution in China. The results also revealed that industrialization and population growth have a positive linkage with soil pollution in China. Having these evidences, the study recommends that fiscal policies should be formulated to increase the budget for soil reduction projects so it can save soil from pollution. Likewise, policymakers must behave to encourage eco-innovation at economic and societal levels to reduce soil pollution.

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1. Introduction

In past 40 years, a rapid growth has been observed in the economy of China. This happens due to accelerated industrialization that further improves the overall productivity. However, on the other hand, it negatively impacts ecological environment especially soil pollution which is increasing insanely in China. It is argued that in comparison with atmospheric pollution and water pollution, soil pollution is characterized by accumulation, delay and concealment, and even a long incubation period

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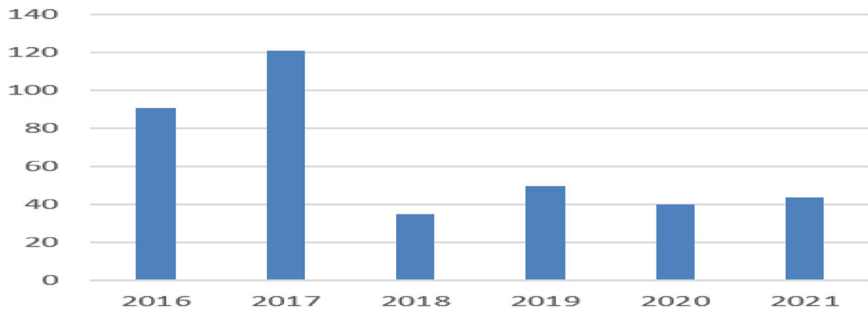

Figure 1. Special fiscal budgets for control of soil pollution in China from 2015 to 2021 (in RMB 100 million).
Source: World development Index.

from pollution behaviors to the outbreak of pollution accidents (Chen et al., 2014; Yang et al., 2014).

According to environmental protection and Ministry of land & resources 2014 reports, the soil survey point has exceeded level 2 requirements of soil environment standard almost 16.1%. In case of agricultural land, the ratio was about 19.4%. According to the report, contaminants including copper, lead, mercury, cadmium, nickel etc. are major pollutants having the ratio of 2.1%, 4.8%, 1.6%, 7.0%, 1.9% respectively. Moreover, pollution due to inorganic pollutants is mostly abundant in China. It is argued that due to anthropogenic activities, heavy metal contamination occurs which create threat to human health particularly in agricultural and industrial region of China (Abdul Hamid et al., 2020; Li et al., 2019).

According to Zhang et al. (2016), China's environmental regulations mainly caters water and air pollution issue. There indeed certain rules exist in environmental protection law, Grass land law, Water pollution law etc. in regard to soil pollution control, however, they are generic in nature, hence, could not be used to build a comprehensive soil management system. However, in recent times, the government of China indeed tightened the laws regarding soil pollution in a hope to create a systematic process. Contrastingly, the Law of the People's Republic of China on the Prevention and Control of Soil Pollution also clarifies the principle of 'accountability' where the person liable for soil pollution is obligated to organize the remediation (Ainou et al., 2022; Chen et al., 2021). In 2020, the Interim Measures for the Identification of Persons Liable for Soil Pollution on Construction Land and the Interim Measures for the Identification of Persons Liable for Soil Pollution on Agricultural Land went into effect to further standardize the procedures and specific operation methods for the identification of persons liable for soil pollution (Ali et al., 2022; Ou & Du, 2022; Sadiq, Ou, et al., 2022). This provision has several implications like only the person liable for soil pollution is the subject of remediation liability in a strict sense. Statistics revealed that in China 16.1% of soil survey points exceeded the Soil Environmental Quality Standard's Level II standards (Bai et al., 2022; Khan et al., 2021; Zhao et al., 2021). Inorganic pollution is most prevalent in China, where it is present in 82.8% of the polluted survey points. Chinese Special Fiscal Budgets for Prevention of Soil Pollution are given in Figure 1.

The debate thus urges to scrutinize the the role of government measures to reduce soil pollution, eco-innovation, and environmental sustainability on soil pollution in China. This way the study may address several gaps that have been found in synthesized literature. 1) Although soil pollution in Chinese context researched although in different times but still not reached its peak as there are a number of its aspects are need to be explored, 2) Abbaszade et al. (2022), investigated the association between soil pollution and human health, whereas the present study will work on remedies which can be effective to control it in China with fresh data set, 3) Qin et al. (2021) the equation consists of soil pollution, government expenditures, eco-innovation, environment sustainability, population growth, and industrialization particularly in China is not tested before in recent time, 4) Delang (2017), investigated the causes of soil pollution, whereas the present study will work on remediation effect on soil pollution, 5) Qin et al. (2021), investigated the association between soil pollution and food safety in China, whereas the present study will work on remediation i.e. government expenditures, eco-innovation, environment sustainability, population growth, and industrialization effect on soil pollution. The significance of the present study are 1) the present study it will shine the spotlight on the adverse effect of soil pollution on the Chines environment, and 2) the present study will also provide help to professional to upgrade their policies with the view to control the soil pollution,3) the present study will also [provide the support to future scholars to examine and explore new aspects of soil pollution which affect the environment and can be controlled through different ways in China.

Structurally, in the first chapter the overall introduction of the study including the study gap and significance will be presented. The second phase will present the evidence about soil pollution, government expenditures, eco-innovation, environment sustainability, population growth, and industrialization in connection with past studies will be discussed. The third chapter of the study will provide the methodology, i.e. the collection of data about soil pollution, government expenditures, eco-innovation, environment sustainability, population growth, and industrialization. After that will the validity of the data will be analyzed. The results received after data analysis will be presented in fourth chapter. Finally, the study conclusion, implications and recommendations will be presented.

2. Literature review

Over the past few decades, soil pollution, because of its persistence and effects on people, animals, and plants has drawn the interest of many researchers. When substances enter the soil, they alter its biology, composition, and fertility, making it less resistant to drought and unusable for farming which is narrated as soil pollution. There are multiple causes of soil pollution like industrial pollution, agricultural activities, acid rain, heavy metals, and oil spills (Chien, 2022a; Delang, 2017). Both natural and human processes and activities can contaminate the soil. However, it is mostly a result of human activity. It happens as a result of a variety of different activities, such as the misuse of pesticides, which causes the soil to lose its fertility, and the presence of too many chemicals, which raise the acidity or alkalinity of the soil and so degrade its quality. Countries all around the globe are putting their maximum efforts to control soil pollution with the view to bringing stability to the environment (Chien, Zhang, et al., 2022; Yongming & Ying, 2018). China is the world factor in the case of industry, therefore, using more chemicals for production and causing more soil pollution. The government of china is worried about it and ensuring laws for controlling soil pollution (Chien, Chau, et al., 2022; Li et al., 2019; Liu et al., 2021).

Human activity-related soil contamination in China poses a hazard to food safety, agricultural production, and public health. To tackle soil contamination, the Chinese government has implemented a number of initiatives, such as 1) the Soil Contamination Prevention and Control Action Plan and 2) By enacting the Law on Soil Pollution Prevention and Control, a piece of law that took 12 years to develop, the nation just made another step in the right direction, 3) The new law will support soil conservation in China in a number of different ways. The legislation first establishes who is legally culpable for soil contamination and offers a framework for making such individuals or organizations accountable. Second, benchmarks for soil contamination levels will be established, and ongoing assessments will show whether local governments are achieving the benchmarks. Thus, Hsu et al. (2021), investigated the data and transparency in pollution eradication in China. The results proposed that the government is expressing much interest in pollution eradication and the recent budget allocated for this is 1.1 trillion $. Moreover, Bulus and Koc (2021), investigated whether FDI and government expenditures allocated for pollution control affect the environment. The results of the study proposed that the more the government is allocating the budget and planning to control the pollution it has the more adverse effect on environmental degradation (i.e. soil pollution).

With the passage of time, technology has secured a core place in every aspect of life. Every aspect of life and business is witnessing changes in terms of innovation according to its modern needs. Agriculture is one of the industries which is directly associated with the soil. Agriculture usually provides raw materials for industry. The nature of the soil will directly affect agriculture which further other aspects associated with it. Soil is one of the factors which is directly associated with the business industry as well as the environment (Ayaz et al., 2021; Chien, 2022b; Kumar et al., 2019). Every industry is introducing innovation according to its need with the view to increase its production with the view to bring balance to the world environment. The developing countries are using traditional ways to increase their production which is causing environmental issues. Whereas the developed countries are employing modern era innovations and technologies which are not only increasing production but also supporting soil, particularly in agriculture (Zhao et al., 2021; 2022). Accordingly, Chikopela et al. (2018), worked on the usage of the innovation for soil fertility. More usage of chemicals results in reduce soil fertility and also affects the environment. Thus, the countries prefer innovations which support production and also bring soil fertility to maintain. If the soil is fertile then it will require fewer chemicals which further turns into pollution. The more and more use of a chemical in soil decreases its fertility but also increases pollution associated with it. Use of soil more than the limit converts soil into black soil. With the passage of time, the use of technology and innovation is increasing with the aim to reduce chemical usage and keep soil fertility maintain (Liu, Lan, et al., 2022; Sadiq, Ngo, et al., 2022). Moreover, innovations have been witnessed which are effective for black soil. In this context: Hou (2021), worked on the usage of technology on the black soil. The results of the study proposed that in the region of black soil in China. The better usage of relevant technology and innovation can cause to bring back soil fertility and also bring balance to environmental degradation. Thus, the innovation can be applied as one of the remedies to control soil pollution.

The world environment is witnessing rapid change over the past few decades. One of the adverse effects is the world environment is getting hotter. This is global warming, which affects almost every aspect of life. The natural resources particularly the soil and water are the key effects of this global warming. In the case of water, the glaciers are melting at a rapid pace and will cause water shortage in future and in the case of soil agricultural cultivation is affecting and causing less or substandard production due to changes in weather conditions. Thus, there is an association between soil pollution and environmental degradation (Arora et al., 2018; Lan et al., 2022; Liu, Yin, et al., 2022). A significant environmental problem brought on by recent worldwide industrialization is the poisoning of soil with harmful metals. Decontamination of heavy metal-contaminated soils is crucial to lowering the dangers involved, maintaining environmental safety, and restoring the ecological balance. Conventional methods for reclaiming such soils are pricy and unfriendly to the environment. A developing technology known as phytoremediation uses green plants to remove toxins from the environment. It is thought to be a more affordable and non-intrusive remediation method than traditional methods. In this context: Ashraf et al. (2019), investigated the environmental sustainability of heavy metal polluted soil and proposed that Conclusion: Phytoremediation of soils contaminated with heavy metals is an effective technique and is required to make the land resource usable for agricultural production. Pollution in agriculture is directly associated with the soil. The more the soil is polluted the more it will affect the environment. Thus, to bring the environment sustainability there is an urgent need to reduce soil/agricultural pollution. Accordingly, Sun et al. (2018), worked on the pollution in agricultural soil and its remedies. A growing number of pesticides are being used in agriculture to protect crops against pests, weeds, and diseases, but up to 80 to 90 per cent of those pesticides are sprayed on non-target vegetation and remain there as pesticide residue, which might pose a serious threat to the agricultural ecosystem. Thus, the environmental sustainability can be achieved by reducing soil pollution.

One of the important factors which affect soil pollution is population growth. Population growth itself is one of the disturbing factors for the entire globe. As soil pollution occurs due to more usage of chemicals like pesticides, ammonia, lead, and nitrate. The increase in population increases the usage of these chemicals due to multiple reasons. Thus, the increase in population cause to increase the soil pollution (Chien, Hsu, et al., 2022; Saha et al., 2017). Land fragmentation and the rising need for food and fuel wood are both directly impacted by population growth. The need for food puts pressure on land expansion and intensification, which in turn impacts soil quality and migratory patterns, which in turn affect deforestation and desertification. In this context: Al-Taai (2021), investigated the causes along with effects of the soil pollution. The results proposed that the increasing population growth is one of the major causes of the increasing soil population in the world. Further, Havugimana et al. (2017), investigated the causes of soil pollution and proposed that the majority of soil pollutants are caused by human activities, including mining, industrial processes, household and business waste, and drugs for both humans and animals. The principal pollutants in soil are heavy metals and synthetic organic compounds, according to various overviews of recent research and case studies. Numerous infections (such as tetanus) and parasites (such as hookworm) that have numerous well-recognized negative effects on human health are also found in soil (Haroon et al., 2021; Kamarudin et al., 2021)

The soil itself is one of the major sources of environmental degradation. With the passage of time, the world is increasing at a rapid pace. The increase in world population caused to increase in their needs. Which includes food, daily usage items like clothing, shoes, beverages, electronics, and electrical gadgets. The major source of production of all these items in anyways linked with the soil like agriculture, and raw material production for industry. Literature proposed that industrialization affects the soil by releasing chemicals (Keshavarzi et al., 2019; Khattak et al., 2021). The rapid increase in the industry is also affecting the environment due to the usage of the extra amount of chemicals for their production. Therefore, agriculture is expanding and introducing multiple ways to not only increase but early productions. The more usage of chemicals for early and more production cause soil pollution which further affects the environment. Bangladesh is expanding its industry with the view to uplifting its economy. This expansion in industry is causing excessive chemical use. In this context: Proshad et al. (2018) investigated the excessive usage of heavy metal toxicity in agriculture in Bangladesh. The study concluded that heavy metal toxicity usage in agriculture is affecting the agricultural soil. Moreover, Ukaogo et al. (2020) investigated the causes of environmental degradation inclusive soil. The results of the study proposed that more usage of chemicals results in affect the soil which further causes to effects the environment. More usage of chemicals through different means like soil affects the environment in a negative way. The population is more and more at risk for a toxic environment and health risks. Thus, Wu et al. (2018), investigated the adverse effect of re-usage of land on health and the de-industrialization in China. The results of the study proposed that the re-usage of land causes adverse health effects and de-industrialization causing to effect environmental degradation.

3. Research methods

The study examines the role of government measures to reduce soil pollution, eco-innovation, and environmental sustainability on soil pollution in China. The study has collected secondary data from WDI, the Chinese soil database, the global economy and the environmental performance index (EPI) China covering the period from 1985 to 2020. Following is the equation that has been constructed understudy variables.

$$SP_t = \alpha_0 + \beta_1 GESP_t + \beta_2 ECI_t + \beta_3 ES_t + \beta_4 PG_t + \beta_5 IND_t + e_t \quad (1)$$

Table 1. Variables with measurements.

S#	Variables	Scale	Sources
01	Soil Pollution	Percentage contaminated land	Chinese Soil Database
02	Government measures to reduce soil pollution	The ratio of government expenditures to reduce soil population to total governmental expenditures	Chinese Soil Database
03	Eco-innovation	Eco-innovation index	The Global Economy
04	Environmental Sustainability	Environmental performance index	EPI China
05	Population Growth	Population growth (Annual percentage)	WDI
06	Industrialization	Industry value add (Percentage of GDP)	WDI

Source: Author estimation.

Where;

SP = Soil Pollution

t = Time Period

GESP = Government Expenditures to reduce Soil Pollution

ECI = Eco-innovation

ES = Environmental Sustainability

PG = Population Growth

IND = Industrialization

The study has taken soil pollution as the main variable and measured with the percentage of contaminated land. Moreover, the study has used three predictors such as government measures to reduce soil pollution measured with ratio of government expenditures to reduce soil population to total governmental expenditures, eco-innovation measured with the eco-innovation index, and environmental sustainability measured as EPI. Table 1 illustrate the detail of study measurements.

The study runs the descriptive statistics to check the details of the variables. Moreover, correlation was performed as well to evaluate the correlation among constructs. In addition, the study checks the unit root to apply the appropriate model via ADF test. The equation is given as below:

$$d(Y_t) = \alpha_0 + \beta t + \gamma Y_{t-1} + d(Y_t(-1)) + \varepsilon_t \tag{2}$$

The ADF test is used to check the unit root individually. Equation for each variable is given below:

Soil Pollution

$$d(SP_t) = \alpha_0 + \beta t + \gamma SP_{t-1} + d(SP_t(-1)) + \varepsilon_t \tag{3}$$

Government expenditure to reduce soil pollution

$$d(GESP_t) = \alpha_0 + \beta t + \gamma GESP_{t-1} + d(GESP_t(-1)) + \varepsilon_t \tag{4}$$

Eco-innovation

$$d(ECI_t) = \alpha_0 + \beta t + \gamma ECI_{t-1} + d(ECI_t(-1)) + \varepsilon_t \tag{5}$$

Environmental Sustainability

$$d(ES_t) = \alpha_0 + \beta t + \gamma ES_{t-1} + d(ES_t(-1)) + \varepsilon_t \quad (6)$$

Population Growth

$$d(PG_t) = \alpha_0 + \beta t + \gamma PG_{t-1} + d(PG_t(-1)) + \varepsilon_t \quad (7)$$

Industrialization

$$d(IND_t) = \alpha_0 + \beta t + \gamma IND_{t-1} + d(IND_t(-1)) + \varepsilon_t \quad (8)$$

The ADF test confirms that the ARDL model is appropriate for the study as it provides the results of short and long-run relationships between the constructs. (Mensah et al., 2019; Tan et al., 2021). Finally, it also controls the issues of heteroscedasticity and auto-correlation. The ARDL equation is given as under:

$$\Delta SP_t = \alpha_0 + \sum \delta_1 \Delta SP_{t-1} + \sum \delta_2 \Delta GESP_{t-1} + \sum \delta_3 \Delta ECI_{t-1} + \sum \delta_4 \Delta ES_{t-1} + \sum \delta_5 \Delta PG_{t-1} + \sum \delta_6 \Delta IND_{t-1} + \varphi_1 SP_{t-1} + \varphi_2 GESP_{t-1} + \varphi_3 ECI_{t-1} + \varphi_4 ES_{t-1} + \varphi_5 PG_{t-1} + \varphi_6 IND_{t-1} + \varepsilon_1 \quad (9)$$

4. Research findings

The study runs descriptive statistics to check the details of the variables. The results indicated that the mean value of SP was 21.432 percent, while the average value of GESP was 33.112 percent, and the ECI mean value was 64.545 percent. In addition, ES mean value is 77.062 percent followed by PG 7.221 percent, IND 4.012 percent. Table 2 illustrates the numbers in detail.

Moreover, the study runs the correlation matrix to check the association among variables. The study results exposed that government expenditures to reduce soil pollution, eco-innovation, and environmental sustainability have a negative association with soil pollution in China. The results also revealed that industrialization and population growth have a positive linkage with soil pollution in China (Table 3).

In addition, the study checks the unit root to apply the appropriate model through ADF test. Findings form Table 4 showcase that SP, GESP, ECI, and PG are stationary at I(0), whereas incase of ES and IND, the stationary was found at I(1).

Table 2. Descriptives.

Variable	Observations	Mean	St. Deviation	Min	Max
SP	36	21.432	2.531	11.542	24.112
GESP	36	33.112	1.542	21.438	39.651
ECI	36	64.545	1.021	53.161	78.792
ES	36	77.062	1.547	65.101	88.778
PG	36	7.221	0.119	4.194	9.281
IND	36	4.012	0.910	3.102	6.771

Source: Author estimation.

Table 3. Matrix of correlations.

Variables	SP	GESP	ECI	ES	PG	IND
SP	1.000					
GESP	−0.543	1.000				
ECI	−0.773	0.549	1.000			
ES	−0.538	0.547	0.441	1.000		
PG	0.421	0.342	0.312	0.717	1.000	
IND	0.442	0.123	0.331	0.444	0.323	1.000

Source: Author estimation.

Table 4. Unit root test.

Augmented Dickey-Fuller Test (ADF)	Level	t-statistics	p-values
SP	I(0)	−2.431	0.032
GESP	I(0)	−3.642	0.021
ECI	I(0)	−2.827	0.030
ES	I(1)	−6.432	0.000
PG	I(0)	−2.191	0.041
IND	I(1)	−5.819	0.000

Source: Author estimation.

Table 5. ARDL bound test.

				Bound test critical values	
Model	F-statistics	Lag	Level of Significance	I(0)	I(1)
SP/(GESP,ECI,ES,PG,IND)	5.78	4	1%	6.12	6.71
			5%	5.13	5.51
			10%	4.21	4.91

Source: Author estimation.

Table 6. Short run.

Variable	Coeff	Std. Er		t-Stat	P-value
D(GESP)	−3.910	2.041		−3.290	.034
D(ECI)	−.639	.122		−5.238	.000
D(ES)	−2.302	1.912		−2.924	.029
D(PG)	2.172	.524		3.191	.011
D(IND)	2.192	.653		2.632	.041
CointEq(-1)*	−.943	.132		−9.417	.00
R-sq	0.518		Mean DV		−0.030
Adj R-sq	0.502		S.D. DV		2.232

Source: Author estimation.

The study also checked the co-integration, findings show that f-statistics 5.78 is greater than critical values at 5% significance level, hence expose the existence of con-integration. These results are given in Table 5.

The study results related to the ARDL model exposed that government expenditures to reduce soil pollution, eco-innovation, and environmental sustainability have a negative association with soil pollution in China in the short-run (See Table 6). The results also revealed that industrialization and population growth have a positive linkage with soil pollution in China in the short-run.

The ARDL model results also exposed that government expenditures to reduce soil pollution, eco-innovation, and environmental sustainability have a negative association with soil pollution in China in the long-run (See Table 7). The results also revealed that industrialization and population growth have a positive linkage with soil pollution in China in the long-run.

Table 7. Long term coefficients.

Variable	Coeff	Std. Er	t-Stat	P-value
GESP	−1.433	.211	−7.834	.00
ECI	−2.873	2.012	−3.827	.021
ES	−.902	.411	−3.628	.00
PG	2.662	2.100	4.329	.032
IND	3.901	2.087	1.669	.043
C	1.092	.311	3.511	.030

Source: Author estimation.

5. Discussions

The results showed that GESP and soil pollution are negatively correlated, hence are proved to be consistent with the previous study by Hsu et al. (2021). The previous study posits that when the government is attentive to the country's environmental quality and makes sufficient expenditures on the programs designed to reduce soil pollution, the causes of soil pollution can be overcome, and soil quality can be protected. These results are also supported by Huynh (2020), which states that when it feels its remediation liability towards the country's land, it spends money on initiating soil protection projects. The sufficient government expenditures on these projects help overcome soil pollution. The results also showed that eco-innovation and soil pollution share negative linkage, hence confirms the evidence of Gente and Pattanaro (2019). They have the opinion that the initiatives to bring ecological-friendly innovation in geographical structure, economic practices, and societies are helpful in reducing different types of environmental pollution. Water management, proper sewerage system, waste management, and reduction of chemical flow assist in reducing soil pollution. These results are also supported by Madaleno et al. (2020). According to this previous study, the countries where eco-innovation is applied to minimize the impacts of human economic and social activities on the environment, the chances of soil pollution can be overcome.

Similarly evidences also show that environmental sustainability is negatively correlation with soil pollution. Findings hence are consistent with Li et al. (2019). The study reveals that when the government and other country inhabitants adopt a behavior to maintain environmental sustainability so that the natural resources can be saved for the future, the environmental pollution is tried to be overcome. Hence, the soil is likely to be saved from pollution. These results are also supported by Singh and Haritash (2019), which state that in environmental sustainability, the components of the environmental structure are secured for accomplishing the needs of the future generation. In this situation, soil pollution can be controlled. The results showed that population growth and soil pollution are positively linked. These results show consistency with Wołejko et al. (2020), which highlight that population growth is the major factor in environmental pollution. The increase in population growth increases the human wastes and chemicals based on human activities, which can emit pollutants affecting soil pollution. These results are also supported by Zwolak et al. (2019), which show that the countries where population growth is high, soil pollution is increasing. The results showed that industrialization has a positive relation to soil pollution. These results are in line with Keshavarzi et al. (2019), which analyze the effect of industrialization on soil quality. The increasing industrial activities like the use of metals, chemicals consumption, poor water system, and waste emissions cause pollution in soil associated. Hence, industrialization increases soil pollution. These results are also supported by C. Li et al. (2020), which highlight that the increase in industrialization causes soil pollution because of deforestation, increased chemicals use, and the outflow of polluted wastes without proper disposal.

6. Conclusion

The study aimed to examine the impact of GESP, eco-innovation, and environmental sustainability with the control factors of population growth and industrialization on soil pollution. Through research in China, information was acquired about GESP, eco-innovation, and environmental sustainability with the control factors of population growth, industrialization, and soil pollution. Results revealed the positive linkage between GESP, eco-innovation, environmental sustainability, and soil pollution. Having these evidence, one could stimulates that when the government makes sufficient expenditures on the programs specially designed for the reduction of soil pollution, this issue can be removed, and soil quality can be enhanced. The study states that the countries where eco-innovation is encouraged to minimize the environmental impacts of human activities, soil pollution can be reduced. The results showed that in environmental sustainability, the structural elements of the environment are protected in order to meet the needs of future generations. Soil contamination, in this instance, is under control. The results showed that population growth and industrialization have a positive association with soil pollution. The study concluded that the increase in population growth increases human activities, which can cause environmental pollution, and there is an increase in soil pollution. The results indicated that increased industrial operations, such as the consumption of chemicals, metals, dirty water flow, and waste emissions, lead to soil pollution.

The current study has empirical implications for the countries which are making an exponential increase in economic activities and have high population growth. These factors have to face environmental pollution, and the present study addresses soil pollution. This study recommends the environmental regulators and government how they must behave while making policies in order to control soil pollution, which can damage natural resources and ultimately affects the health of living beings. There is a guideline that fiscal policies should be formulated to increase the budget for soil reduction projects so it can save soil from pollution. Likewise, policymakers must behave to encourage eco-innovation at economic and societal levels to reduce soil pollution. The environmental regulators and government must try to achieve environmental sustainability, which can be effective in reducing soil pollution. Moreover, with effective policies, industrialization and population growth must manage to reduce soil pollution.

Limitations are also the part of study, hence, scholars and academics are expected to remove these limitations with increased efforts and literary skills. First, the current study examines the role of limited factors like GESP, eco-innovation, and environmental sustainability in soil pollution. Many other factors like green finance, R&D

expenditures, plantation, and corporate governance can have a crucial role in reducing soil pollution. For this reason, the scope of the study is limited. These factors must also be analyzed to estimate the ability to overcome soil pollution. In this study, the data was collected from China to construct the relation between GESP, eco-innovation, environmental sustainability, population growth, industrialization, and soil pollution. The data from a single country cannot present valid results for all economies. This lack of generalizability can be removed by analyzing the nexus among the abovementioned factors in different countries. So, future authors must pay attention on this topic.

Disclosure statement

The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

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