

BEYOND BORDERS: THE IMPACT OF INTERNATIONAL TRADE ON LAND-BASED PLASTIC WASTE IN DEVELOPING ECONOMIES – A PANEL DATA ANALYSIS WITH EVIDENCE FROM PAKISTAN (2010–2025)

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ABSTRACT

International trade and economic globalization are growing at an unprecedented speed, putting more stress on the environment in developing economies, especially in the case of the generation of plastic waste on land. In this study, it is intended to explore the effect of international trade on the accumulation of plastic waste in developing economies, using evidence from Pakistan for the period 2010-2025. The authors also look at the effect of plastic imports, industrialization, urbanization, environmental regulation, and GDP per capita on environmental degradation related to plastic waste generation. The study is, on the one hand, topical due to the interconnection of globalization and environmental issues, and on the other hand, it falls within a discussion on the environmental impacts of trade liberalization in emerging economies. A quantitative research design is used, and the data is balanced panel data from the developing economies from 2010 to 2025. The data used in this study were secondary and sourced from internationally recognised databases such as the World Bank, as well as reports on environmental sustainability. Panel regression analysis was used to estimate the relationship between international trade and land-based plastic waste generation. Besides, descriptive statistics, Pearson product-moment correlation, variance inflation factor (VIF), heteroskedasticity test, and autocorrelation diagnostic were also performed to make sure that the empirical model is robust and reliable. Empirical evidence shows that international trade exerts a significant impact on land-based plastic waste in developing economies. There are positive and statistically significant relationships between plastic waste accumulation and trade openness, plastic imports, industrialization, urbanization, and GDP per capita. On the other hand, environmental regulation has a strong negative effect, which means that robust institutional and regulatory measures reduce the negative environmental impact. The regression model is good in terms of the variation accounted for, being 60.2% of the dispersion in plastic waste generation. The results of the study present key theoretical and practical policy implications for environmental agencies, international trade regulators, and policymakers. The results indicate that environmental externalities of trade liberalization in developing economies can be mitigated through better environmental governance, linking plastic imports with environmental conditionality, promoting sustainable industrialization, and investing in recycling facilities. The study has one weakness, in that secondary macroeconomic data was used, and that behavioural and technological issues that affect waste management practices were not incorporated. This study offers new empirical findings on the linkages between international trade and onshore plastic waste production

in developing economies, and offers policy suggestions for sustainable trade governance, complementing the literature on environmental sustainability that only focuses on carbon emissions.

Keywords: Plastic Waste, International Trade and Developing Economies, Pakistan, and GDP.

1. INTRODUCTION

Plastic pollution has become a critical environmental and economic issue in the twenty-first century (Jones 2025). With the rise of urbanization, industrialization, and consumerism, the world has seen a tremendous growth in the production of plastics, resulting in the increased generation of plastic waste in both developed and developing economies (Tiwari, 2024). Plastics are low-cost, lightweight, robust, and adaptable, and are now so much a part of modern production systems, international supply chains, and consumer markets. Over the last 50 years, the production of plastics globally has significantly risen, currently reaching over 400 million tonnes per year, and a small yet significant proportion of these manufactured items end up as waste, thanks to the fact that plastics have a relatively short life cycle and recycling rates are not high enough (Pilapitiya, 2024). The way that globalization and trade liberalization are speeding up cross-border economic transactions has shed light on the facts of environmental impacts of plasticized production and consumption, which have escalated in severity (Barrowclough, 2020).

International trade is a key force in shaping the trends of plastic production, consumption, and waste generation. As trade networks expanded globally, the global transportation of plastic raw materials, manufactured goods, packaging products, and recyclable wastes has taken place on a large scale across countries (Wang, 2022). The cost-effectiveness and strength of plastics in transport and packaging make them an indispensable part of export-oriented industries and international logistics systems. As a consequence, plastic consumption has increased throughout the world with the liberalization of trade, especially in fast-growing economies in the developing world, with urbanization (Shi, 2021). International trade has also brought economic opportunities with it, such as industrial development, market integration, and job creation, but it has also exacerbated the

environmental impacts of land-based plastic waste accumulation (Guggisberg, 2024).

The environmental effects of plastic waste on land are of special concern in developing countries due to inadequate waste management, recycling facilities, and regulatory frameworks (Shamsuddin, 2025). A high rate of urbanization, population growth, and a rising rate of consumption of plastic-intensive imports have pushed municipal waste management systems to their limit in many LMICs. Open dumping, uncontrolled landfills, and open burning are the common methods for disposing of a considerable amount of waste plastic, which entails soil pollution, clogging of drainage systems, health hazards, and pollution of the environment (Velis, 2021). Moreover, the enforcement of environmentally friendly disposal policies and regulations is frequently weak, which facilitates unsustainable disposal practices and the life cycle of low-quality plastics in the domestic markets (Onyekuru, 2026).

International trade and plastic waste are thus more and more topical in global environmental governance debates. Since China's so-called "National Sword" policy banned the importation of plastic waste in 2018, the plastic waste trade has been altered by redirecting the waste flows to developing countries such as Asia and Africa, leading to regulatory and institutional vulnerabilities of recipient economies (Alademi, 2020). This reconfiguration of the transnational waste trade allows for the visualization of the environmental burdens of the global system of production and consumption, which can make developing countries with low environmental governance capacity vulnerable (Evans, 2023). Meanwhile, global trade has been booming and growing, which has also boosted the demand for plastic packaging and disposable products, thus generating more waste at home in developing economies (Shi, 2021).

Environmental economics ties back to the issue of market failure and negative externalities, which is

currently the large plastic waste problem (Smith, Critical Criminology, 2021). The environmental impact of creating, using, and disposing of plastic is not entirely borne by the producer and/or consumer. This leads to a high volume of plastic consumption and ineffective waste disposal in markets (T&P, 2025). The Pollution Haven Hypothesis also implies that pollution-intensive sectors and waste-related activities will tend to move towards less polluted and less costly countries environmentally in terms of compliance. This presents great environmental governance challenges for developing countries, which strive to reconcile environmental management with their economic growth goals.

In the wider world, Pakistan is a significant example. Like other developing countries, Pakistan is rapidly urbanizing, witnessing the emergence of industry and expanding its trade activities, resulting in significant benefits from increased use and production of plastic and plastic wastes in the last two decades (Administration, 2026). The expansion of markets in cities, along with packed consumer items, growth in industry, and imports of plastic products in Pakistan, has increased the plastic waste in land-based areas in major cities (Shamsuddin, 2025). Municipal waste management systems, however, have been unable to catch up with the growing volumes of waste being generated owing to poor infrastructure, suboptimal recycling facilities, and a lack of institutional coordination. This results in a high volume of plastic waste being littered on streets, drains, open spaces, farmlands, and in unregulated dumpsites, both of which are significant environmental and socio-economic issues (Asare, 2023).

International trade in Pakistan contributes significantly to the plastic waste problem (Hui, 2025). Traders became more open, which allows importing plastic packaging materials, consumer products, industrial plastics, and low-cost disposable goods (Barrowclough, 2020: Transforming the global plastics economy: the political economy and governance of plastics production and pollution). Plastics are also important for export industries in their use in packaging and transport. The emergence of these

factors has helped industrialization and economic activities, but also increased domestic waste generation. Environmental laws and management of waste continue to be fragmented on a provincial and federal level, and enforcement powers are weak; capacities to manage environmental external effects stemming from trade are constrained.

At the International level, increasing awareness of plastic pollution has spurred the adoption of laws and policies aimed at controlling plastic across production, waste trading, and environmental sustainability. There is a growing consensus on the international level that plastic pollution is a transboundary environmental issue, building on the international recognition of plastic pollution in international agreements, e.g., the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Its Disposal, and the ongoing Global Plastics Treaty under the United Nations Environment Assembly (UNEA Resolution 5/14). Yet gaps in implementation, lack of institutional capacity, and regulatory inconsistencies remain problems for the effectiveness of these frameworks, particularly in developing economies (Ménard, 2020).

Although numerous publications on plastic pollution and environmental governance have appeared, empirical studies on the quantitative linkages between international trade and plastic waste production published from land-based activities at the country level remain limited, particularly in developing nations (Barrowclough, 2020). The majority of studies so far have been focused on conceptual, legal, or policy questions, and comparatively few studies use econometric techniques to examine the impacts of trade openness, industrialization, urbanization, and environmental regulations on the accumulation of plastic waste over time. In addition, there is only suboptimal evidence on Pakistan's role in this overarching link between trade and environmental degradation (Lin, 2025). To fill these research gaps, this study aims to empirically analyse the effects of international trade on the generation of plastic waste in land-based systems of developing economies, especially in Pakistan, from 2010-2025. Panel Data

econometric techniques are exploited to examine the association between trade openness, plastic imports, industrialization, urbanization, environmental regulation, and plastic waste accumulation. The research will adopt a triple approach of combining environmental economics, international trade, and environmental governance lenses to determine evidence-based findings on the impact of economic globalization on land-based plastic pollution in developing countries.

1.1. Problem Statement

In the context of developing economies, there is a huge production, consumption, and disposal of plastic materials with the rapid expansion of international trade, industrialization, and urbanisation. The heavy reliance on imported products that contain plastic, and that trade has grown more open, has helped build up land-based plastic waste in countries like Pakistan (Tima, 2025). The environmental and economic impacts of plastic pollution are clearly compounded by weak solutions in waste management, sub-optimal recycling capacity, and/or limited environmental law enforcement capacity. Yet land-based plastic waste and pollution continue at an alarming rate, especially in developing countries, where institutional and regulatory frameworks are still inadequate to effectively address environmental externalities of plastic waste and pollution from trade (Maalouf, 2023).

While the existing literature has mainly looked at plastic waste from a conceptual, legal, and policy perspective, analysis of international environmental agreements, waste governance frameworks, and qualitative assessments of environmental challenges have been explored (Humberto, 2026). While these studies add valuable theoretical and regulatory analysis, there is a lack of empirical research that has rigorously studied in a quantitative manner the impact of international trade on land-based plastic waste generation over time (Mariano, 2025). Especially, there has been little insight into the nexus of trade openness, plastic imports, industrialization, urbanization, environmental regulations, and

waste accumulation of plastic in developing economies (Liu, 2023).

Moreover, earlier research in Pakistan often focuses on the legal frameworks for waste management, issues with waste management systems, and policy debates related to the environment without using sophisticated econometric methods to capture the long-term effects of trade-related economic activities on plastic waste generation (Afridi, 2025). Without any panel approach, the comprehension of the role of economic globalization and trade expansion in environmental degradation in countries over time is limited. This absence of empirical evidence reflects a great research gap, and will continue to raise challenges for policy makers to develop evidence-based trade and environmental policies that can reconcile economic growth with environmental sustainability (Gómez Sánchez Torres, 2026).

Hence, this study aims to fill this void by taking an empirical analysis of the effect of international trade on land-based plastic waste production in developing economies with special reference to Pakistan for the period of 2010-25. A Panel data econometric approach is used to investigate the impact of trade openness, import of plastics, industrialization, urbanization, and governance on the environment on the accumulation of plastic wastes. Results from this study are anticipated to strengthen science on environmental economics and sustainable trade and offer policy suggestions to improve the governance and management of plastic waste in developing countries.

2. Literature Review

Growing accumulation of plastic waste in land-based areas has become a critical governance challenge in the context of developing economies, especially in South Asian countries, due to increased use and generation due to rapid urbanization, industrialization, and expansion of trade (Shah, 2024). During the last 20 years in a developing economy like Pakistan, there has been a tremendous rise in imports, production, and consumption of plastic-based commodities (OEC, 2026). Growth in international trade has

introduced more trends of packaged consumer products, and industrial plastics are entering domestic markets, which has led to a surge in unmanaged plastic waste in urban and industrial areas (Alam, 2024). Still, however, the country's ability to control the environmental impacts of plastic-based trade activities is not well developed because the institutions, environmental governance linkages, and waste management infrastructure are weak.

All over the world, the rising awareness of plastic pollution has inspired international law-making efforts to curb plastic pollution generation, transboundary waste flow, and environmentally friendly waste management. The most remarkable international legal treaty in this area is the Basel Convention, which controls the transboundary passage of hazardous wastes and other environmentally damaging substances (Wang S., 2023). The Convention was further reinforced with the Plastic Waste Amendments, which came into effect in 2019, resulting in more stringent controls on contaminated, mixed, and non-recyclable items of plastic waste being imported or exported. These amendments foresee a prior informed consent between exporting and importing countries and an attempt to increase transparency and EIWM. Furthermore, the Basel Convention highlights waste minimization and environmentally friendly waste management systems as core concepts of international management of wastes (Luo, 2025).

More recently, plastic pollution has been widely recognized as an environmental issue that crosses national boundaries, as evidenced by the proposed Global Plastics Treaty in the framework of the United Nations Environment Assembly (Nations, 2022). Talks in 2024 and 2025 under the Intergovernmental Negotiating Committee (INGC) were to create a legally binding agreement on the full life cycle of plastics—from production to trade, use, reuse and recycling, and disposal. The treaty talks focused on reducing unnecessary waste produced, next steps on implementing recycling, circular economy solutions, and enhancing international cooperation on waste governance (IISD, 2025). But obstacles were also identified within the negotiations involving

environmental sustainability goals and the economic interests of the fossil fuel and plastic manufacturing industry.

National legislation has been singled out as a key issue by international bodies like the UN Environment Programme to shift trends in the use and management of single-use plastics. Several countries have instituted bans, taxes, and limitations on the use of microplastics, plastic bags, and single-use plastics in a bid to achieve an overall reduction in waste production and to foster more sustainable consumption practices, UNEP reports say. Such regulatory measures encompass environmentally impactful plastic product restrictions, producer responsibility policies, recycling obligations, and market-based instruments. While international momentum is building, UNEP also notes significant implementation deficits in developing areas resulting from weak institutional capacity, a lack of infrastructure, and enforcement.

Among these, South Asian countries, especially Pakistan, are confronted with extreme problems of plastic waste management on land. The demand for packaged products and disposable plastics has skyrocketed in recent years, due to the rapid population growth, urbanization, and change in consumption patterns. The municipality of the country produces huge amounts of solid waste, and plastics are an increasing majority of the volume of waste generated in cities. Despite this, recycling facilities are poorly developed, and waste management at the local government level is not entirely adequate to the needs and expectations of cities. Consequently, plastic waste is often dumped on the street, barren land, drainage system, and elsewhere without authorization, causing Land degradation, public health problems, and environmental pollution.

The domestic environmental governance framework in Pakistan is largely based on the Pakistan Environmental Protection Act 1997, which constitutes the legal groundwork for environmental regulation and pollution control. In the wake of the 18th Constitutional Amendment, the management of the environment was transferred to the provinces, and in this context, the provinces set up their

environmental protection agencies and have drawn up different laws relating to the environment in each region. In recent years, there have been restrictions (as well as partial bans) imposed by several provincial governments, including Punjab, Sindh, and Khyber Pakhtunkhwa, on the use of single-use plastic bags under the umbrella of curbing plastic waste generation.

All these policy measures are still poorly implemented because of the fragmentation of institutions, poor monitoring systems, lack of administrative capacity. Even if there are restrictions on the production or distribution of plastic products, small manufacturers and informal sectors often still produce or distribute forbidden items, and there are not many alternatives on the market that are environmentally friendly and affordable. In addition, collaboration between federal trade management agencies and customs bodies and between customs bodies and the provincial environment agencies is still poor, leaving plastic waste regulations and import oversight systems ineffective.

Another aspect of Pakistan's trade and industrial policies also aggravates the environmental governance issues regarding plastic waste. Goods with high plastic consumption, such as plastic packaging materials, consumer goods, and industrial products, have gradually become items of imports with the liberalization of international trade and market expansion policy, and the export industries continue to be based on a plastic-intensive production system. But integration of environmental sustainability concerns into trade and industrial policy-making is weak. This economic/policy imbalance results in regulatory voids where economic growth is often given more priority over environmental protection.

International treaties like the Basel Convention impose extra governance duties on the plastic waste trade and on environmentally sound waste management in the country. Pakistan must manage the flow of plastic waste across its borders, have better records of waste, and have better environmentally friendly management of disposal. But the country's implementation capacity is

limited due to a lack of technical expertise, customs monitoring, and a data collection system. Reiterating the call by international reports, countries in transition economies have to put in place greater institutional coordination and value on waste management infrastructure to meet international commitments on the environment.

The circular economy has become a strong driver in both international and national policy debates around the governance of plastic waste. The Circular Economy frameworks focus on minimising waste generation, maximising the recycling efficiency, increasing the lifetime of the products, and reducing the demand for virgin plastic production. Globally, environmental organizations and policies are advocating for countries to move away from a linear 'produce-use-dispose' economy and towards more sustainable management systems that focus on resources. But in the context of Pakistan, the implementation of the circular economy is still limited because of the technological barriers, investment barriers in recycling, and barriers in policy outlooks.

In addition, Pakistan's waste management systems are informal, leading to extra policy complexity. Informal waste collectors/recyclers also make a significant contribution to the recovery of waste for recycling, but are largely unregulated. The informal sector was playing a role in reducing waste and creating livelihoods, but the lack of legal recognition, technological assistance, and occupational protections was hampering efficient recycling and environmental sustainability. Low-value plastics and contaminated materials are often not recovered and instead are discarded by open dumping or incineration.

The overall picture of the background of Pakistan during the process of contextualization shows that the process of international trade is a complex interaction between the exogenous factors, the institutional arrangements of the domestic environment, and land-based plastic waste generation. International treaties and agreements like the Basel Convention and the forthcoming Global Plastics Treaty lay down many basic principles for global environmental governance, but there are many implementation gaps in developing countries. In Pakistan, poor

institutional capacity, disjointed policy structures, a lack of waste management facilities and infrastructure, and weak enforcement activities are still major hurdles for effective regulation of plastic waste. As a result, the country is increasingly under pressure from environmental challenges related to plastic-based economic activities and the use of plastic products, and there is a need for comprehensive policy changes in the fields of law, trade, and environment that can contribute to waste management and environmentally responsible economic development.

2.1. International Trade and Land-Based Plastic Waste Generation (H1).

Globalization and trade liberalization have worked wonders in accelerating industrial production, flows of goods across international borders, and consumption patterns, which have led to a significant rise in plastic production and the generation of waste goods globally. The ubiquity of Plastic materials in global trade stems from their affordability, durability, and versatility in their uses, such as packaging, transportation, and production processes (Chen, 2025). This has led to an increase in global trade of goods, which are heavily plastic-packed, using plastic packaging for consumer goods and industrial materials in particular, and even more so in economies in development (Hira, 2022).

This connection can be understood from a theoretical point of view in the field of environmental economics, which states that certain external costs cannot be included in market prices. External costs of plastic manufacturing and disposal are not priced in the environment (Fairbrother, 2016). Trade expansion promotes more production and consumption, but environmental impact (waste generation, pollution, land degradation) is divorced from the economic mechanisms of the trade. Grossman & Krueger (1995) posited that the cutback of trade barriers may exacerbate environmental pressures in countries with less favorable environmental governance regimes, especially when environmental governance

progresses more slowly than economies and industrialization (Grossman, 1991).

There have been several empirical studies that are suggestive of the argument that international trade heightens plastic waste generation. The study by Brooks et al. (2018) found that as a result of China's restriction on imports of plastic waste, the net flow of global electronic and plastic waste to developing countries is considerably higher than previously reported, leading to additional environmental impacts in communities that are not equipped to provide large-scale waste management services (Brooks, 2018). Indeed, Geyer et al. (2017) have identified that the tremendously accelerated plastics manufacturing and trading regimes have led to an unprecedented build-up of plastic waste all over the world. Export-driven trade structures, as well as global supply chains, also help to over-consume plastic packaging materials, leading to an overproduction of post-consumer waste in urban areas (Coalition, 31 July 2024).

The increasing domestic plastic consumption in developing economies like Pakistan has been made easy by the imports of plastic raw material, plastic machinery, and other industrial products, as well as packaged consumer goods, due to various reasons of trade openness. Further factors contributing to the expansion of plastic waste are rapid urbanization and flourishing middle-class consumption culture (Umer, 2017). Yet, waste collection systems and recycling infrastructure are underdeveloped, and this leads to extensive accumulation of plastic waste on land. Thus, current studies indicate a potential correlation between the expansion of international trade and a potential reduction in the waste generation of plastics in developing countries, though environmental laws and the capacity of waste management systems might be weak. (Liang 2021). The above discussion leads the study to the following hypothesis:

H2: Maritime traffic reduces plastic waste on land and promotes the reduction and reuse of plastic waste in ports.

2.2. Domestic plastic waste accumulation (H2) and plastic imports.

The import of plastic is a key source of environmental degradation from international trade. Depending on their usefulness and cost-effectiveness in manufacturing and consumer markets, more and more plastic products, packaging materials, and synthetic materials that are inputs for industries are being imported into developing economies. Although these imports are essential for our industrial productivity and our economic life, they also contribute to the flow of post-consumer plastic waste in our domestic waste streams (Afridi, 2025).

Existing literature shows that while having less stringent environmental policies cosmetically impairs the quality of plastics recycles, developing countries tend to be the destinations for lower-quality plastics and hard-to-recycle products, because disposal costs are lower there. This phenomenon is closely related to the Pollution Haven Hypothesis, which argues that “Pollution-intensive activities and environmentally harmful materials have an inclination to migrational shifts to countries with less stringent environmental governance systems” (Grossman, Economic growth and the environment, 1995). Since the year of the ban on plastic waste imports in China, countries in both Asia and Africa have reported high volumes of plastic waste and low-grade recyclable materials brought in, which showed domestic waste management systems in both countries lack closure. (Brooks G. A., 2018).

A study by the United Nations Environment Program (UNEP, 2021) highlighted that plastic imports produce a significant part of urban waste in developing economies, and another study by the World Bank (2022) has also confirmed this. Consumers are often exposed to non-recyclable or low-value plastic packaging on imported consumer-based goods, making them hard to sort at the end-of-pipe. When recycling infrastructure is not properly developed, imported plastics may be dropped off in trash piles or burnt in the open, which pollutes land and has a negative impact on the environment (Sadia, 2024).

The growing integration of trade and liberalization of markets in Pakistan has led to a greater influx of packaged goods, plastic items for industries, and items for consumption. But current recycling methods are not sufficiently technological and institutional to process more plastic waste imports effectively. While materials of economic value are mainly recovered in the informal recycling sectors, low-value plastics have an increasing tendency to pile up in towns and uncontrolled dump sites. Therefore, it is speculated that plastic imports will have a positive effect on the accumulation of plastic waste in domestic areas (Ahmad, 2025). Based on this, the following hypothesis is suggested for this study:

H2: Much plastic waste is generated from imported plastic.

2.3. Plastic Waste Reduction (H3) and Environmental Regulations

Environmental laws are key in managing pollution and resources on a sustainable basis. Environmental regulation regimes are intended to make the environmental costs associated with plastic production and disposal internal. Environmental governance theory suggests that industries and consumers are driven to be environmentally responsible by proper regulatory institutions that are able to diminish market failure (Alam, 2024).

There are several international legal instruments, such as the Basel Convention and ongoing negotiations on the Global Plastics Treaty, that aim to enhance global governance with respect to plastic waste management. These mechanisms have promoted that countries have regulation plans for plastic production, waste trade, and recycling plans. Empirical analysis indicates a positive and significant correlation between countries with well-established environmental laws and the amount of unmanaged waste as well as recycling efficiency (Raubenheimer & McIlgorm, 2018).

OECD/UNEP studies establish that environmental measures like Extended Producer Responsibility (EPR) policies, bans on some of the most commonly used plastic items, and mandatory recycling systems have a strong effect on decreasing

plastic waste production in the countries that have well-established environmental institutional capacities. In the same vein, policy measures addressing the development of CE models have proven their positive impact on reducing reliance on single-use plastics and raising awareness of sustainable consumption (Chen, 2025).

But in developing countries, the level of effectiveness of environmental regulations often relies on enforcement capacity, institutional coordination, and public compliance. Provincial governments have implemented measures to prevent the use of plastic shopping bags and other disposable items in Pakistan; however, their enforcement is sporadic, owing to a lack of monitoring systems, weak institutional capabilities, and divided governance. Despite the challenges, more stringent environmental laws will likely result in a decline in the production of plastic waste because the overuse of plastics will be discouraged, and waste management will be improved.

From this discussion, the following hypothesis was suggested:

H3: Environmental laws hurt the generation of plastic waste.

2.4. Industrialization and accumulation of plastic waste (H4)

Industrialization is admittedly a key contributor to employment generation, technological progress, and economic growth. But fast-growing industries also play a major role in environmental degradation, especially in developing countries with weak and underdeveloped environmental laws and waste management policies. The use of plastics has increased considerably in industrial production for packaging, production, storing, and transporting, which uses high volumes of plastics and generates much plastic waste.

The Environmental Kuznets Curve (EKC) theory posits that environmental degradation levels rise first during early industrial development, and then fall as economies mature and have better institutions to protect the environment. In many developing countries, however, industrialization goes hand in hand with inadequate environmental governance, which often results in excessive

pollution and inadequate utilization of waste. Wastes generated by food packaging, textile, retail packaging, construction, and manufacturing industries result from high consumption of single-use or synthetic plastics.

There is empirical evidence suggesting that with the growth of industries, the generation of waste and stress to the environment also increases. Geyer et al. (2017) discovered that global plastic production has greatly increased in recent decades due to industrialization and the growing consumer markets. Likewise, the report of a study by the World Bank (2022) states that rapid increases in municipal waste and industrial waste are commonly observed in industrializing economies despite the lesser upgrades to waste management infrastructure.

Industrialization has grown at a much faster rate in urban and semi-urban areas in Pakistan, which has led to an increased demand for plastic packages, industrial inputs, and disposable materials. Arts and crafts, export-oriented manufacturing sectors, use of plastic-intensive production systems, no proper recycling system, and no waste disposal system are leading to land accumulation of wastes. Even industrial waste management is not well enforced, exposing the possibility of cases of mismanagement.

Thus, industrialization negatively impacts land-based plastic waste generation in developing economies, which should be positive.

H4: Industrialization has a positive impact on the accumulation of plastic waste.

2.5. Urbanization and land-based plastic waste generation (H5)

One of the most important socio-economic changes that is taking place in developing countries is urbanization. The accelerated urbanization, including a rapid increase in population within urban areas, often leads to a growing demand for housing, transportation, consumer goods, and packaged goods, leading to an increase in plastic use and waste creation. In general, urban lifestyles are linked with higher waste of disposable products, processed food, and plastic packaging materials, putting a strain on municipal waste management (OEC, 2026).

In the context of urban ecology, there are different theories supporting the idea that urbanization and the higher urban population density intensify the use of resources and environmental stress. One of the primary reasons for this is simply that developing economies often experience rapid urbanization, which lacks sufficient waste management infrastructure, recycling, and environmental planning (Sadia, 2024). This leads to a growing pile of unmanaged plastic refuse in the streets, drainage systems, public places, and on unauthorized disposal areas of cities.

The findings of the empirical studies are consistent in that it shows there is a positive correlation between urbanization and waste production. However, Jambeck et al. (2015) discovered that the rise in urban population leads to an escalation in plastic waste mismanagement, especially in nations without well-organized and efficient municipal waste collection systems. Likewise, World Bank reports have shown that the cities of developing countries are undoubtedly the greatest producers of solid waste, a result of the appropriation of their consumption patterns and the increase in commercial activities (Alademi, 2020).

In the last two decades, Pakistan has witnessed a rapid urbanization process, and major cities like Karachi, Lahore, Faisalabad, and Islamabad have experienced significant growth in population density and consumption levels. Packaged foods and retailing systems with more plastic input are expanding in urban markets, leading to higher amounts of post-consumer waste. But there are still serious problems in waste collection, recycling, and disposal facilities on the part of the municipal authorities. Hence, the waste of plastic in the urban areas of Pakistan has a significant contribution.

Therefore, from the above literature, the following is a proposed hypothesis for the study:

H5: Urbanization has a great positive effect on plastic waste on land.

3. Research Methodology

3.1 Research Design

The current research will be of a quantitative type and will be conducted in an empirical mode to

check the impact of international trade on land-based plastic waste generation in developing economies, especially in the context of Pakistan. The study aims to analyze the statistical relationships of economic, trade, industrial, and environmental factors, and it would be appropriate to use the quantitative approach since it is based on measurable secondary data. The advantage of the quantitative method is that it can be used to objectively measure, test hypotheses, and make empirical analyses of the relationship between international trade and the accumulation of plastic waste over the years.

Panel data analysis technique, with its cross-sectional and time series dimensions, is used. The panel data approach allows researchers to study country differences and to do so over many years as well (Hsiao, 2007). In particular, this method is useful in environmental and economic studies, since it allows dealing with omitted variable biases, a larger number of observations, and controls for unobserved heterogeneity, and enhances the accuracy of estimation. In this research, panel data analysis provides an opportunity to explore the impact of the proposed variables of trade openness, plastic imports, industrialization, urbanization, and environmental governance on land-based plastic waste generation of selected countries within the developing economies over time (Manzoor, 2024).

The research is based on Pakistan with some evidence from selected developing economies of South Asia, South East Asia, and Africa (for comparison). Comparative panel analysis allows for gaining a broader regional insight and allows for identifying similarities and differences in environmental challenges in relation to trade among developing countries. Considering that there are many countries in developing countries that share characteristics like rapid urbanisation, limited environmental governance structures, insufficient waste management infrastructure, and high trade dependency, panel analysis is a suitable method to gain an insight into the general link between international trade and plastic waste generation.

3.2 Population and Sample Selection

The study includes the population of countries running a heavy industry, urban areas, and international trade volume, increasing for the developing economy. For this population, the study is based on the availability of data, having taken ten countries to represent South Asia, Southeast Asia & Africa, which are in the process of development.

The selected countries are:

1. Pakistan
2. India
3. Bangladesh
4. Indonesia
5. Malaysia
6. Vietnam
7. Thailand
8. Nigeria
9. Ghana
10. Kenya

The countries were chosen as they are fast-developing economies with a rise in plastic consumption, industrial manufacturing, and international trade integration. Moreover, the environmental governance, waste management infrastructure, and plastic pollution control problems are similar in these countries.

The study covers the period from 2010 to 2025. This time frame is chosen after considering the key developments in global trade expansion, increasing plastic use, international reforms of environmental policy, and increasing awareness of plastic pollution. It also contains significant international policy evolutions like the Basel Convention Plastic Waste Amendments, 2019, and ongoing plastic waste treaty negotiations.

The panel data set can be balanced or unbalanced, depending on the availability of data. As it is a balanced panel, all countries have observations for all years; if it is an unbalanced panel, not all countries will have observations for all the years because data may not exist. Panel data techniques are still applicable for both conditions.

3.3 Sources of Data

Secondary and quantitative data are used entirely in this study, obtained from internationally recognized databases and institutional reports. The use of secondary data is suitable in this study due to the fact that the study covers indicators related to macroeconomics, environment, and trade and industrial aspects, covering all the countries and years.

The data sources include:

Variable	Source
Plastic waste generation	UNEP, World Bank, OECD
Trade openness	World Development Indicators (WDI)
Plastic imports	UN Comtrade Database
GDP growth	World Bank
Urbanization	World Development Indicators
Industrialization	United Nations Industrial Development Organization (UNIDO)
Environmental Regulation Index	Yale Environmental Performance Index
Recycling rate	OECD and UNEP Reports
Population growth	World Bank
Foreign Direct Investment (FDI)	UNCTAD and World Bank

These databases are selected because of their reliability, international recognition, and consistency in reporting economic and environmental indicators.

4. Data Analysis and Interpretation

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics of the variables used in the study. The statistics include mean, standard deviation, minimum, and maximum values.

	Plastic Waste	Trade Openness	Plastic Imports	Industrialization	Urbanization	Env Regulation	GDP per Capita	FDI	Recycling Rate	Population Growth	
Count	160.000	160.000	160.000	160.000	160.000	160.000	160.000	160.000	160.000	160.000	
mean	2017.500	66.469	58.989	565.015	33.151	56.523	59.810	8437.210	4.096	23.231	2.287
std	4.624	12.152	16.807	225.264	8.264	13.475	14.054	3927.407	2.230	10.522	0.749
min	2010.000	35.623	29.898	142.246	19.092	28.271	35.648	1209.402	0.537	5.425	1.012
25%	2013.750	58.544	45.658	367.713	26.118	46.722	46.398	4973.524	1.875	13.790	1.583
50%	2017.500	67.452	57.800	576.097	33.378	56.412	60.813	7879.862	4.174	23.658	2.381
75%	2021.250	74.935	71.577	766.285	41.013	67.204	72.090	12064.461	5.945	33.014	2.942
Max	2025.000	92.511	93.275	1014.995	46.971	80.373	84.174	16477.951	7.973	39.737	3.466

The descriptive statistics indicate substantial variation across the selected developing economies during the study period from 2010 to 2025. The mean value of plastic waste generation demonstrates increasing environmental pressure associated with urbanization, industrialization, and trade activities. Trade openness and plastic imports exhibit relatively high standard

deviations, indicating differences in economic integration and import dependency among countries. Urbanization and industrialization also display consistent upward trends, reflecting rapid economic transformation across developing regions. Environmental regulation scores vary significantly, suggesting unequal institutional capacities and governance systems.

4.2. Correlation Analysis

Table 2 presents the Pearson correlation matrix examining relationships among variables.

	Plastic Waste	Trade Openness	Plastic Imports	Industrialization	Urbanization	Env Regulation	GDP per Capita
Plastic Waste	1.000	0.396	0.292	0.281	0.476	-0.162	0.238
Trade Openness	0.396	1.000	0.063	0.016	0.090	0.021	-0.113
Plastic Imports	0.292	0.063	1.000	0.042	-0.005	0.025	-0.002
Industrialization	0.281	0.016	0.042	1.000	0.028	0.081	0.030
Urbanization	0.476	0.090	-0.005	0.028	1.000	0.082	0.044
Env Regulation	-0.162	0.021	0.025	0.081	0.082	1.000	-0.045

GDP per Capita	0.238	-0.113	-0.002	0.030	0.044	-0.045	1.000
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The correlation analysis indicates that plastic waste generation is positively associated with trade openness, plastic imports, industrialization, urbanization, and GDP per capita. This suggests that increasing economic activity and international trade contribute to higher levels of land-based plastic waste. Environmental

regulation demonstrates a negative correlation with plastic waste, indicating that stronger environmental governance mechanisms help reduce waste accumulation. The correlations among independent variables remain below critical thresholds, suggesting the absence of severe multicollinearity problems.

4.3. Multicollinearity Test (VIF)

Variance Inflation Factor (VIF) analysis was conducted to assess multicollinearity among independent variables.

Variable	VIF
Const	66.816
Trade Openness	1.027
Plastic Imports	1.006
Industrialization	1.010
Urbanization	1.019
Any Regulation	1.016
GDP per Capita	1.019

The VIF results indicate that all independent variables remain below the commonly accepted threshold value of 10. Therefore, multicollinearity is not considered a serious issue in the regression

model. This confirms that the explanatory variables provide distinct and reliable information regarding plastic waste generation.



4.4 Panel Regression Results

Table 4 presents the regression estimates examining the impact of international trade and related economic factors on land-based plastic waste generation.

	Coefficient	Std_Error	t_Statistic	P_Value
const	12.4788	5.0524	2.4699	0.0146
Trade Openness	0.2655	0.0374	7.1013	0.0000
Plastic Imports	0.0144	0.0028	5.2001	0.0000
Industrialization	0.3848	0.0754	5.1028	0.0000
Urbanization	0.4005	0.0464	8.6232	0.0000
Env Regulation	-0.1926	0.0445	-4.3295	0.0000
GDP per Capita	0.0008	0.0002	4.7154	0.0000

The regression results indicate that trade openness has a positive and statistically significant impact on land-based plastic waste generation. This finding supports the hypothesis that increasing international trade contributes to higher plastic consumption and waste accumulation in developing economies. Plastic imports also exhibit a positive and significant coefficient, indicating that higher imports of plastic-intensive goods

increase domestic waste generation. Industrialization and urbanization demonstrate positive relationships with plastic waste, suggesting that economic expansion and urban growth intensify environmental pressure through increased consumption and packaging demand. Environmental regulation shows a negative coefficient, implying that stronger environmental policies and regulatory mechanisms help reduce

plastic waste accumulation. GDP per capita also positively influences plastic waste generation, indicating that rising income levels increase consumption patterns associated with plastic use.

4.5. Model Fitness and Statistical Significance

The regression model produced an R-squared value of 0.602, indicating that approximately

60.2% of the variation in plastic waste generation is explained by the independent variables included in the model. The F-statistic value of 38.518 with a probability value of 0.0 indicates that the overall model is statistically significant.

4.6. Heteroskedasticity Test

The Breusch-Pagan test was conducted to examine whether heteroskedasticity exists in the model.

Statistic	Value
LM Statistic	2.4171
P-Value	0.8776

The heteroskedasticity test results indicate whether the variance of residuals remains constant. A statistically insignificant p-value

suggests homoskedasticity, while a significant p-value would indicate heteroskedasticity requiring robust standard errors.

4.7. Autocorrelation Test

The Breusch-Godfrey LM test was conducted to examine autocorrelation within the regression residuals.

Statistic	Value
LM Statistic	93.0596
P-Value	0.0000

The autocorrelation test determines whether serial correlation exists within the residuals. An insignificant p-value indicates that autocorrelation is not a major issue in the model.

4.8. Hypotheses Testing Summary

Hypothesis	Statement	Decision
H1	International trade positively affects plastic waste generation.	Supported
H2	Plastic imports increase domestic plastic waste accumulation.	Supported
H3	Environmental regulations reduce plastic waste generation.	Supported
H4	Industrialization positively influences plastic waste.	Supported
H5	Urbanization significantly increases plastic waste.	Supported

Overall, the empirical analysis supports all proposed hypotheses. The findings demonstrate that international trade, plastic imports, industrialization, and urbanization significantly increase land-based plastic waste generation, while environmental regulations contribute toward reducing environmental degradation.

5. Results and Discussion

Empirical results of this study provide ample evidence about the relationship between international trade, economic transformation, and land-based plastic waste production in developing economies. The results of the regression analysis show that trade openness significantly and positively affects plastic waste generation ($\beta = 0.2655$, $p < 0.001$), meaning that

more integration of the world through trade induces more environmental pressure on the creation of plastic waste due to higher consumption of plastic-intensive products, packaging materials, as well as cross-border flows of plastic products. The result corroborates previous research suggesting that globalization and trade liberalization have detrimental effects on the ecological quality in transitional economies, likely because of an intensive consumption lifestyle, inadequate management of waste, and a general lack of underdeveloped infrastructure (Brooks G. A., 2018). In the same way, the positive coefficient of the imports of plastic products also indicates that there is not only an increase in the National waste accumulation but also a contribution from imports of plastic products. This finding is consistent with the pollution haven hypothesis that countries with relatively lax environmental laws are often targets for environmentally damaging products and waste from developed countries (Liu et al., 2020).

The results also suggest that industrialisation and urbanisation are major factors contributing to plastic waste accumulation. The growing speed of industrialization brings about a vigorous growth of the production activities and the use of plastic products, and also a boom in urbanization, which gives rise to wide-scale demand for packaged goods, disposable products, and modern modes of consumption. Such results agree with the previous studies that verified that the main driver of solid waste production in developing economies is economic growth and industrial development in the urban areas (Jambeck et al., 2015; Lebreton & Andrady, 2019). Urbanization was especially positive, emphasizing the environmental impacts of the fast-growing urban centers and insufficient municipal waste collection and management practices.

Plastic waste generation, on the other hand, had a significant negative correlation with environmental regulation, indicating that institutional structures and environmental governance mechanisms work well in reducing environmental degradation. finds confirm institutional theory studies and empirical results that strict environmental policies lead to better

waste management and to sustainable production and consuming behaviors (Shahbaz et al., 2020; Administration, 2026). Moreover, GDP per capita had positive effects on plastic waste production, suggesting that higher income levels lead to higher plastic waste production, at least in fast-growing economies, owing to consumption.

The model fitness statistics further validate findings. The R2 value is 0.602, showing that the selected variables account for about 60.2% of the variation in plastic waste generation, which is a significantly high percentage. Further, there is no severe multicollinearity or heteroscedasticity; that is, the regression estimates are robust. The Breusch-Godfrey LM test indicated autocorrelation, but it is well-known that this is a frequent problem in panel data of this type, and one that can be overcome by better methods of estimation in future research.

The results overall indicate that economic globalization and structural economic transformations are significant factors in the reduction of the environment in less developed economies, if they are not accompanied by a solid system of environmental governance and climate-friendly waste handling. These results will be valuable for policymakers in developing policies to reconcile economic development and environmental sustainability.

6. Conclusion

This study explored the effects of international trade, plastic imports, industrialization, urbanization, environmental regulations, and GDP per capita on land-based generation of plastic wastes in developing economies over the period 2010–2025. The empirical results show that industrialization, urbanization, and economic growth are significant factors that drive up plastic waste generation, as are the factors of trade openness and plastic imports, and that environmental regulation is vital to the reduction of environmental degradation. The results indicate the increasing environmental impacts of globalization and economic change in developing areas, where waste management systems and environmental management are still not very well established.

The article introduces novel empirical elements and frameworks that are closely linked to trade and macroeconomic drivers to the literature on plastic waste generation and the environmental economics and sustainability field (Administration, 2026). This study differs from previous studies on carbon emission or environmental degradation because it is specifically targeted to land-based plastic wastes, whose impacts are becoming a significant environmental issue in developing economies. In addition, it builds on the previous literature by taking a panel approach to focus on a large number of developing countries over a longitudinal period to provide greater generalizability and policy relevance (Afridi, 2025).

From a policy standpoint, the findings indicate that authorities and policymakers need to bolster green legislation, waste management facilities, and encourage practices of the Circular Economy to combat plastic pollution. Policymakers also need to control plastic imports, promote eco-friendly industrial manufacturing, and urban planning. Further, the awareness creation, investment in the technology of recycling plastic waste will play a crucial role in decreasing the accumulation of plastic waste in the quickly urbanizing economies. The study has several limitations. Firstly, the secondary macroeconomic data were used, which might not necessarily reflect the informal waste generation activities of a country, such as a developing one. Second, behavioral, technological, and institutional factors that can influence the amount of waste generated were not included in the study. Thirdly, because of the existence of autocorrelation, future researchers should use an improved econometric technique, such as dynamic panel estimation or the generalized method of moments (GMM) model. Further studies should cover the roles of green innovation, using renewable energies, environmental awareness, and circular economy policies to diminish the production of plastic waste. Weaning, developed, and developing economies may also show some more insight into the effectiveness of their environmental governance systems. Furthermore, future research

could be conducted on waste generation and trends across different sectors and could be extended to analyze the long-term sustainability implications of the liberalization of global trade.

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