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Integrated Policy Strategies and Regional Policy Coordination for Resilient, Green and Transformative Development: Supporting Selected Asian BRI Partner Countries to Achieve 2030 Sustainable Development Agenda

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Micro-sectoral Study on Kitchenware: Diagnostic analysis of Stoves, Aluminium and Plastic Kitchenware

Contents

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Introduction

Pakistan has become a significant actor in kitchenware manufacturing. Kitchenware production in Gujranwala, Karachi, Sialkot, and Wazirabad has grown significantly. A good part of production is exported but the bulk stays in the country with the whole range of the quality, reflecting the socioeconomic reality of Pakistan. One can expect that the many factories producing low-quality materials would produce hazards both for their consumers and environment. Low quality kitchenware also directly releases metals and, in many cases, the low quality makes cleaning difficult, requiring more detergents to wash them, augmenting the un-green impact of detergents.

The social aspect of kitchenware use is also important as the manufacturer may be designing and manufacturing utensils regardless of how people use them. In our social practice, in most of the households, pots and utensils have multipurpose use; a pot is used in the morning to boil milk; it may be used in the afternoon to cook curry and in the evening to make a dessert. With a low-quality pot, harmful fumes and smoke particularly affect the health of the elderly and children. Multi-purpose pots usually produce a large amount of black soot, which is toxic for the environment.

In Pakistan, the green transformation of cooking ware has received relatively less policy attention as compared to the sectors like Textiles, Plastics etc. There is a need to bring kitchenware, which includes utensils of any form used for cooking or baking, and appliances such as stoves, and plastic tableware to the mainstream discussions. This is considered the most ignored carbon-emitting sector in Pakistan. According to Ritchie (2020), Globally food production is responsible for 26% of global greenhouse gas emissions of which 6% is from food waste. This study, analyzing the key sub-sectors of Kitchenware seeks to fill this gap and help promote green, clean and lean production.

1. Stoves

Pakistanis use stoves, an essential element of any kitchen, made of brass or aluminium. The vents in the bottom allow the gas to flow out and ignite. This is the burner's size and number of holes, which control the size and intensity of the flame. The use of stoves in our kitchen is one of the big green problems in Pakistan due to its significant contribution to environmental and public health hazards. Due to the use of poor-quality stoves, a large amount of our gas is wasted, as it is found that Pakistan wastes 30-40 billion cubic feet of gas in kitchens due to poor-quality stoves, which are causing a financial loss of $300 million and are responsible for 2% of methane gas. (Sohail, 2023). Cooking with any type of stove throws tiny particles and gases, which are a mix of solids and liquids in the air. Gas stoves are considered more polluting than electric and induction stoves because they emit more harmful pollutants.

1.1. Current Trends and Situation

Most of the households in Pakistan use gas stoves because of low-priced gas supply. Historically, the low gas prices have resulted in excessive and wasteful use of gas. Though the prices of gas now have substantially increased but still the uptake of electric and induction stoves is slow though the former produce twice as many of the harmful particles as the flame itself generates them. When we use a gas stove, the burning gas in the stove contributes to carbon emissions which include the release of methane and nitrous oxide. It is estimated that stoves release 0.8% to 1.3% of their natural gas into

the atmosphere as unburned methane (Lebel et al., 2022). These gases trap heat in our atmosphere which contributes to rising temperature and global warming. These gases do pollute the environment, but in addition, they also affect human health as nitrous oxide can cause breathing problems, particularly for those with asthma, and may also impact our lung health. Chronic exposure to these particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer.

1.2. Policy Landscape

The government is aware that the poor design of gas stoves is the root cause of gas leakages, and inefficient energy use in cooking in households, restaurants, cafes, or roadside street food vendors. The Pakistan Standards and Quality Control Authority, PSQCA, Ministry of Science and Technology, government of Pakistan, has made detailed provisions in the form of Standards for Domestic Gas Stoves. However, the compliance remains very poor. PSQCA little formal arrangements for implementing the standards it has prescribed for testing stoves and cooking ranges for gas leakages.

1.3. Diagnostic Analysis

1.3.1. Gas Stoves

One study found that homes with gas stoves have a 42% higher chance of having asthma symptoms to their children. According to the Stanford University, the pollutants from burning natural gas stoves are an overlooked source of greenhouse gas emissions, despite the fact that it releases of methane, which is significantly more potent greenhouse gas than carbon dioxide, contributing to the production of the ozone layer (World Economic Forum, 2022). The stove nozzles are most often loose and become the source of emitting methane. Most of the manufacturers do not take into account PS&QCA standards while manufacturing stoves. A good percentage of stoves is made in the informal sector or in small workshops, with the technicians unfamiliar with standards. Also, to stay price-competitive, they use low-quality materials.

Besides the faults of manufacturers, the consumers themselves also ignore or don't pay much attention to check the quality of their stoves. Our fieldwork found through the conversations with technicians running gas stove repair shops that the consumers bring their stoves for repair only when these becomes dangerous or unbearable.

Due to the poor quality of stoves, there are growing number of incidents of explosion of the cylinders. Such explosions cause injuries, burns, and even deaths. In the bigger markets, bazaars the explosion of these gas cylinders is even more harmful as the fire can spread quickly across a wide area, increasing the risk of injuries and loss of life. In Punjab alone, there have been 328 incidents of fire in the last two years, due to the leakage and explosion of the LPG cylinders, attributed mainly to the low-quality stoves. Pakistan faces the problem of low gas pressure particularly in winter due to a spike in demand. Many people use low quality gas compressors, which cause more serious explosion to their high-pressure level.

1.3.2. Traditional biomass stoves

Nowadays more people use gas or electric stoves but when we look into the rural areas most people still use biomass stoves. Burning of biomass fuel for stoves also emits large amounts of pollutants which include particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO2), lead, mercury, and other hazardous air pollutants (HAPs). Poor combustion of biomass in stoves due to incomplete burning causes three main environmental problems; first in the form of energy waste as

insufficient burning uses more biomass and more natural resources needed to be harvested; secondly in the form of health risks as harmful chemicals form incomplete combustion are harmful to inhale; thirdly these gases directly or indirectly affect greenhouse gases which contribute to global warming (Smith, 1994). In other words, contrary to the popular belief, there is no clean gas i.e. natural, liquefied natural gas. Though, these gases emit relatively less greenhouse gases and other harmful gases. In this sense, these are cleaner. But we should remember that they do contribute to environmental pollution, which has its own hazards, which become significant in the Pakistani context. So, they are less green.

1.3.3. Electric stoves

Electric stove seems to do better than gas stoves, but they also have an environmental impact. During cooking, electric stoves can emit three times more carbon dioxide than gas stoves but it is safer because it does not emit gas when it is turned off (Katz, 2023). The recent designs of pots are heavily influenced by the designs of Western pots built for induction cooking. The induction cooking method is usually considered environmentally friendly as it lowers the carbon footprint. The induction cooking method is climate friendly as it uses fewer detergents as they are easy to clean, is more energy efficient, and plays a role in green-house gas reduction. But, in Pakistani context, this can contribute to a higher carbon footprint as the use of these flat-bottom pots and pans results in inefficient cooking and heat loss. This heat loss happens due to the flat surface of pots and pans as the food is scattered which causes the heat to spread over and heat a larger surface area. Moreover, if we use these flat pots and pans on a smaller heat source like on a gas stove then the hotspot is in the center which leads to uneven distribution of heat. Conversations with manufacturers found that consumers usually buy these flat pots to show their status, forcing these manufacturers to produce these inefficient pots and pans, making it harder to green the sector.

1.4. Policy Recommendations

a) PSQCA needs to improve the implementation process on its already made regulations on the quality of domestic gas stoves.

b) On the regional level, PSQCA needs to have regular inspections arrangement with the possibility of closure of the non-compliant factories and or penalties. Mushroom presence of informal producers is a challenge but there is a need to force all the manufactures to have a brand and register it with PSQCA.

c) Given the importance of the sector in green transformation, a Manufacturing Mission for better stoves is proposed to be launched in ach province bringing together the organizations like PCSIR, PSQCA, Universities of Engineering and Technology, Housing Societies, Tech Entrepreneurs and Green Finance providers.

d) Green innovation need to be promoted in the sector by incentivizing energy-efficient, safe, multiple fuels use stoves. With a carefully designed Carbon Credit Scheme, old inefficient stoves maybe replaced with new smart stoves.

2. Aluminium Kitchenware

Aluminum is a highly recyclable, light metal with high heat and electricity conductivity, due to which its use in different sectors has thrived over time. Global aluminum industry accounts for 2% global GHG emissions. In recent times, there has been significant progress in reducing greenhouse gas emissions and energy use in the global aluminum

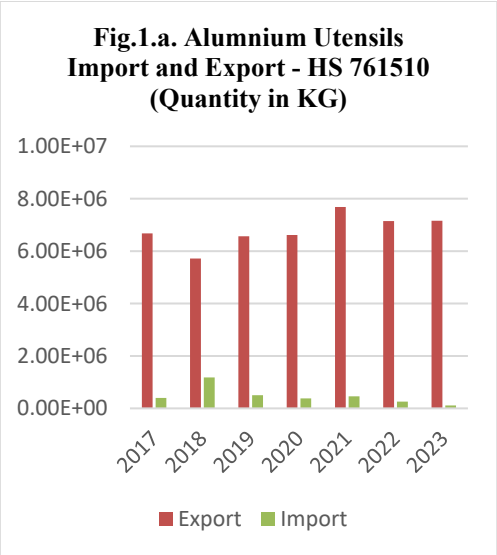
industry. The International Aluminum Institute reports that the emissions from the sector did not grow despite an increase in the production in the year 2023 (International Aluminium Institute, 2022). A study on iron and steel industry energy efficiency and conservation potential from Pakistan, found that SME sector employs less formal energy management practices and have no environment and quality control systems in place. The main barrier in energy efficiency and conservation practices in the steel and iron industries of Pakistan were technological and knowledge and awareness (Yousuf, Irshad & Umair, 2024). Similar observations are made for Aluminium industry in Pakistan, as this cluster is mainly operating at SME level with semi-mechanized processes.

Aluminum is also used to make various cooking utensils, including pots, frying pans, baking dishes, pressure cookers, food packaging etc. For enhancing the durability and creating a non-stick surface, these utensils are often either anodized or coated. Although this reduces the health risks due to food's direct contact with aluminum to some extent, the chemical used in coating could be highly toxic and wears off with time.

The International Energy Agency reports that aluminum industry is one of the five highest energy intensive industries and third most impactful industry on climate change amongst metal industries (Yi et al., 2022). Our Study seeks to analyze the entire life-cycle of aluminum utensils to assess the cleanness of production process, supply chain and intra-industry trade as well as end product's sustainable use and circularity. One distinct, unfortunate part of the Aluminium sector is that it accounts for third highest number of occupational injuries at 19.1%, in overall manufacturing in Pakistan. (PBS, 2021).
The aluminum utensils industry in Pakistan is labor intensive and not technologically sophisticated. As per a study of SMEDA in 2019, Gujranwala city accounts for 90% of the production of aluminum utensils, employing around 18,000 people (SMEDA, 2019).

2.1. Current Trends and Situation

In 2023, Pakistan's exports in Aluminum Utensils stood at 22nd in the world. However, the trade value in Aluminum exports declined from 27.9 Million USD in 2022 to 24.7 Million USD in 2023 (WITS, 2023). This decline is observed despite an increase in the quantity of Aluminum Export (Fig 1). Pakistan's share in global aluminum utensils exports was 0.40% in terms of trade value for the year 2023. The top three destinations for Pakistan's exports in this cluster are UAE, KSA and UK (Fig. 2). A study by Pakistan Business Council shows that Pakistan's aluminum utensils have high potential in Middle Eastern and European Markets, but Pakistani products fetched lower price in the global market due to the absence of Quality Controls (PBC, 2023). Another study on the sector also points out the absence of quality assurance measures for raw material used, manufacturing process and testing of the end product (SMEDA, 2019).



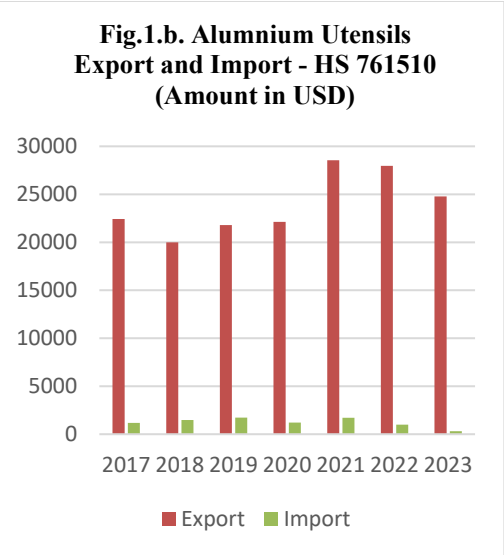


Figure 1. (a) and (b)

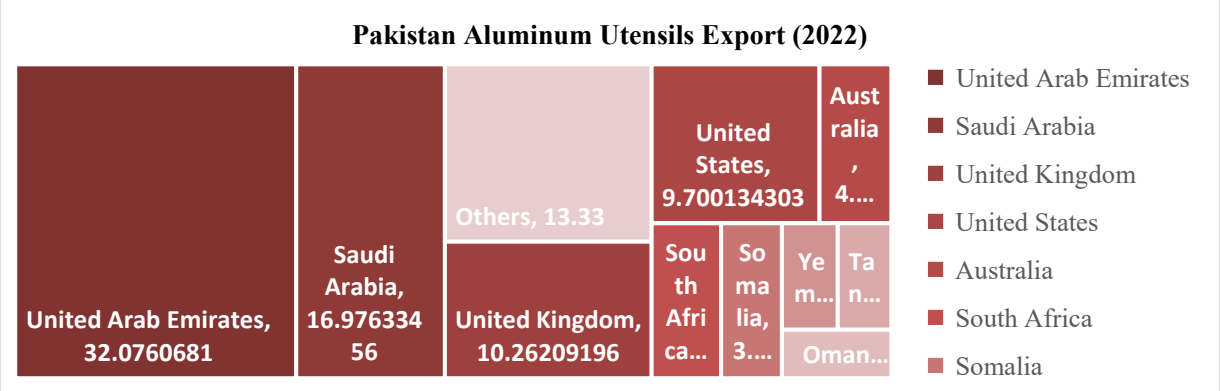


Figure 2.

2.1.1. Types of Aluminum Utensils Manufactured

The aluminum utensils manufactured in Pakistan are categorized into four types as per the techniques of manufacturing and product finishing (see table 1). The manufacturing process of pressed aluminum is least costly, whereas anodized aluminum utensils are most costly to make. The sectoral study by SMEDA on this cluster shows that of the total produce 70% is exported, while 30% is sold in Domestic Market (SMEDA, 2019). The same study determined profit margin of 8-10% (See table 2).

Table 1.

Type	***Affordability***	***Health Risk***	***Manufacturing technique***	***Durability***
Pressed	Highest	High aluminum leaching can be above WHO thresholds	Pure Aluminum is pressed into desired shape	Reactive to Acidic Food Corrodes easily Surface bents with long term use
Die Cast	High	Comparatively less aluminum leaching	Molten aluminum alloy is molded into desired shape	Thicker and more resistant to damage Corrodes with long term use
Coated *(Non-stick)*	High	Below threshold aluminum leaching But chemical coating exposes to hazardous chemicals	From most to least hazardous coatings: PTFE *PUF* CBM Ceramic	98% reduces the leaching of Aluminum Non-stick but chemical coating wears off with long term use
Anodized *(Non-stick)*	Low	Below threshold aluminum leaching	Electro-chemical Treatment	Harder than steel Non-stick Non-reactive to acidic foods

Table 2. Adapted from Cluster "Profile Aluminium Utensils, Gujranwala", SMEDA MOIP (2019)

Expenditure and Revenue of Aluminum Utensils

Raw material	56%
Labor	17%
Energy (Gas & Electricity)	17%
Administrative & Operational	10%
Profit Margin	8-10%

2.2. Policy Landscape

As per the National Energy Efficiency and Conservation Authority (NEECA), the consumption of energy by the industrial sector in Pakistan is 15% more for each $ of GDP than India (Yousuf, Irshad & Umair, 2024). The NEECA National Action Plan for Energy Efficiency and Conservation 2022-2023, confirms that industrial sector is highly energy intensive, with a total Energy Efficiency and Conservation potential of 2.81 MTOE (NEECA, 2023). (See Fig. 3)

The action plan broadly identifies priority action areas mainly for textile, cement, steel, sugar mills and leather industry but not Aluminum. The focus on SME units in the action plan is also very limited. However, the following priority action areas in the National Action Plan 2023-2030 are relevant to the energy efficiency and conservation in Aluminum Industry:

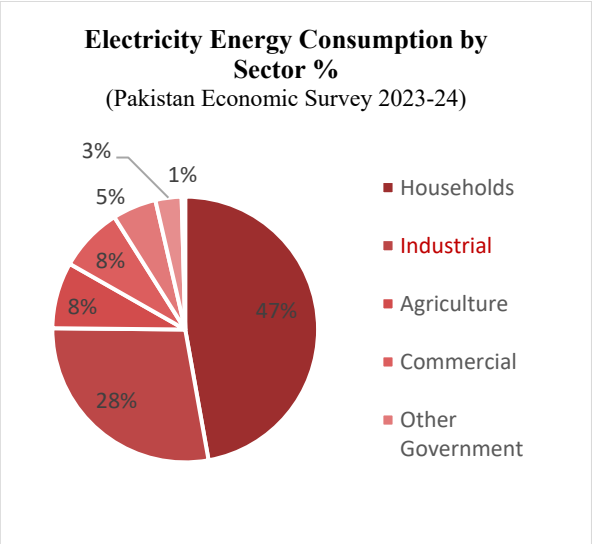


Figure 3.

Action Area	***Actions***
Regulatory action 1:	Ban on the manufacture, sale, and import of motors having lower than International Efficiency Class 2 (IE2) standard
Regulatory action 2:	Deployment of energy management system (EnMS) and energy managers
Capacity Action 1:	Tune-up & Retrofitting of Gas and Coal based Industrial Boilers, Furnaces, and Kilns
Capacity Action 2:	Tune-up & Retrofitting of Gas and Furnace Oil based Captive Generator Sets

Table 3. National Action Plan 2023 -2030

The following Acts deal with different energy aspects of the industry:

- Pakistan Environmental Protection Act, 1997 (PEPA-97)
- National Climate Change Act, 2017

The following Standards relate to the industry in terms of energy efficiency:

- National Environmental Quality Standards, based on self-monitoring and reporting
- Punjab Environmental Quality Standards, based on self-monitoring and reporting
- Minimum Energy Performance Standards (MEPS) of (NEECA)

2.3. Diagnostic Analysis

The aluminum manufacturing process and its various steps and environmental impact in making four different varieties of utensils is analysed. The aluminum supply chain is analyzed with respect to energy efficiency, environmental impact, GHG emission, productivity and social compliance.

2.3.1. Sourcing of Raw Material: Aluminum scraps and waste

The raw material used for the production of aluminum utensils mainly (90-95%) comes from import of aluminum in the form of aluminum wastes and scraps (PBS, 2023). Pakistan does have Bauxites but the known reserves are not very high in quantity or quality. [74 Million tons as compared to 7.4 Billion tons in Guinee and 5.8 in Vietnam.] Aluminum is expensive if imported in the pure form; hence the metal suppliers in Pakistan mainly import aluminum wastes and scraps (See fig 4), risking the increase of the exposure to other metals such as arsenic, cadmium and lead. The aluminium ingots produced by recycling from domestic aluminium scrap collection are not supplied to the local industry and are mostly exported out of country, reducing the availability of raw material for the domestic industry (ITC 2023).

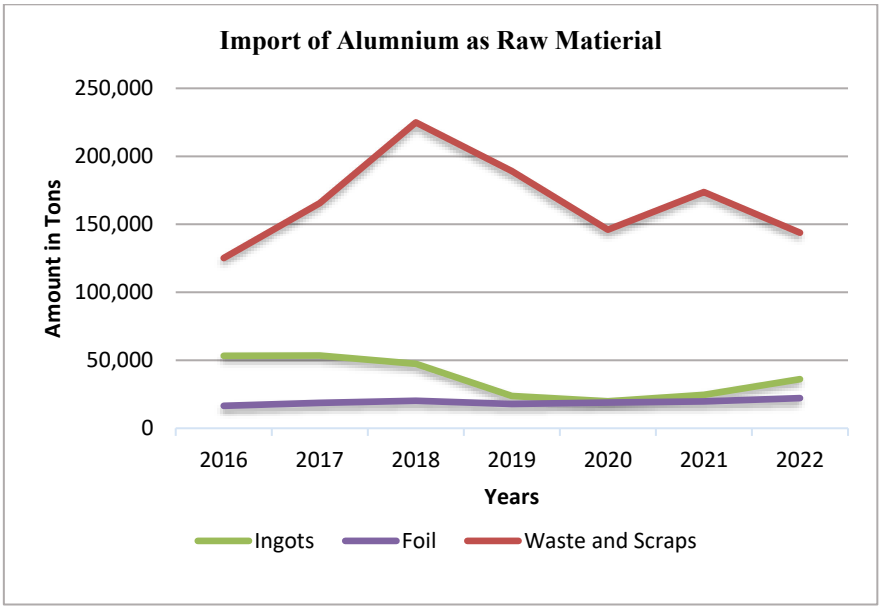


Figure 4.

- Environmental Compliance: The secondary use aluminum comes with a lot of solid waste, which is sorted mechanically in the initial processing phase. In many cases, instead of circular recycling, this waste, harmful for the environmental is disposed of in landfills.

- GHG emissions: The emission associated with import of aluminum are unaccounted for.

- Recycling: Though the emissions of GHG can be reduced if aluminum recycling is increased domestically but, according to a technical study on aluminum flows and stock in Pakistan, the recycling rate of aluminum domestically is only 30% (Rabab et al., 2024).

- Productivity: Limitation of sourcing aluminum only through import of aluminum scraps increase impact of global commodity cycles on costing of the product, which in turn hits the purchasing preference for the low-priced for many.

2.3.2. Melting in Natural Gas Furnace

The aluminum scraps are melted in natural gas fired furnaces to produce molten aluminum to separate aluminum from other components in the scrap. The machinery used in this process is usually old with low technology level. Due to the absence of a covering on the molten metal, a lot of metal is lost by oxidation of upper layer. In most of the cases, the metal is not recycled.

- Environmental compliance: The waste generated in this step is in the form of dross aluminum and slag, whereas GHG emissions and PM result from high temperature melting of aluminum. The industries currently lack procedures to recycle this aluminum. The untreated disposal of aluminum waste from the multiple industries of both aluminum utensils and automotive industries has led to contamination of drinking water in Gujranwala. A study on drinking water contamination with heavy metals in Gujranwala shows that the mean concentration of aluminum in drinking water there was above both WHO and PSQCA standards and the highest in Zone 2 (Afzal et al., 2024).

- Productivity: In Pakistan, conventional method of recycling is employed to recover aluminum from waste and scraps. A comparative study on different methods of recycling aluminum shows that the proportion of aluminum recovered using conventional recycling methods method is as low as 52% (Samuel, 2003). The rest becomes waste as part of slag and dross aluminum. As per a sectoral study on Aluminum Utensils by SMEDA, the recovery rate of aluminum is only 50-60% (SMEDA, 2019).

Table 4. Loss of Aluminum during scrap melting process. Source: (Samuel, 2003).

Conventional method of recycling aluminum from Aluminum Scraps

State of Aluminum	**Process**	**Waste**
Aluminum Scraps	Conventional Recycling Melting in Gas or Oil Fired Furnaces	38% metal is lost in slag
Aluminum molten	Conventional Recycling Casting	8%
Aluminum ingots	Forging & extrusion	20%
Total Metal recovered	52%	

- Social Compliance: The manual machinery and exposure to intense heat results in high rate of injuries to the workers. The lack of heat control mechanism and non-provision of personal protective equipment to many workers increases the risk to injuries.
- Energy efficiency: The conventional recycling production process from aluminum scraps used in Pakistan uses high energy, increasing its carbon footprint, whereas, recycling through semi-direct and direct methods has a lower environmental impact (Duflou et al., 2015). Moreover, these techniques require only 5-10% of the energy compared to the conventional process and recovers 95% of the metal compared to conventional recycling technique (Al-Alimi, 2024).

2.3.3. Pressing and Die-Casting

The **pressing technique** involves multiple steps to make the aluminum utensil. Firstly, the molten metal is converted into blocks which are then converted into metal sheets through hot and cold rolling machines. The sheets are cut through circular cutting machines and thereafter, shaped through hydraulic press machine. The next step involves cutting of excess and smoothening of edges through a spinning machine. After the procedures of cleaning, manual sanding, buffing and lathe machine procedures, the pressed aluminum utensil is fitted with handles and is packaged for sale.

Comparatively, the **die-cast method** involves fewer number of steps and converts molten metal directly into the desired shape through die-molds. The shaped utensil is removed from the mold once cooled down. The die-cast technique provides higher output and better-quality product, using advanced technology and the larger manufacturing units employ this technique.

- Environmental compliance: The new scrap produced in the pressing technique in cutting and spinning machines is recycled within the plant.
- Energy efficiency: The energy management systems are usually not in place. The sector overall, does not meet the energy efficiency criteria of International Efficiency Class 2 (IE2) standard.
-
- Social Compliance: A ten-country study on inexpensive non-corrosion resistant aluminum cookware made from aluminum waste and scraps (Pressed aluminum utensils) finds that it is not just a source of high level of exposure to aluminum, but also lead, arsenic and cadmium (Weidenhamer, 2017). The study conducted leaching tests on 42 cookware items, of which half of the items detected arsenic from 3 to 10 ug per 250 Ml, exceeding the minimum thresholds and forty of the forty two items detected more than six times the WHO threshold for aluminum weekly intake.[1] The WHO recommended Provisional Tolerable Weekly Intake levels for aluminum is 20 ug per day for a 70 Kg adult. The non-anodized and non-coated utensils in local market as inexpensive options do not usually conform to standards of leaching of metals.

2.3.4. Health Risks from low quality aluminium utensils

2.3.4.1. Health risks of Aluminum leaching from non-corrosion resistant cooking utensils

Although aluminum is a natural element, aluminum cookware could cause various metals to get released into our foods at high temperatures, specially due to the factors such as acidic foods, green leafy vegetables, and old pots and pans. Chronic exposure to high levels of aluminum causes Brain disorders, like Alzheimer’s Disease, Hormone disruption, kidney problems, and cancer. Various studies found high levels of aluminum in the brain cells of Alzheimer's patients but this link is not clear however they are proven harmful effects of aluminum on cardiovascular health.

2.3.4.2. Health risks of Non-stick Aluminium Utensils

The aluminum utensils produced in casting is either anodized or coated to make it corrosion resistant and non-stick. The **anodizing process** uses sulfuric and nitric acid. Later on, it is boiled in calcium hydro oxide mix to clean the surface. **The process releases SO2 and NOx as air pollutants**. However, the end product is highly durable and has less GHG footprint (Australian Anodising Association, 2010) The health risks of anodized non-stick pans is also minimal compared to the coating variant.

The chemicals such as PTEF and PUF are used to produce **coated non-stick aluminum utensils**. These non-stick pans have shorter life-cycle and lead to exposure to aluminum and fumes from chemical used in coating if not treated with care. The PTFE coated non-stick pans are known for potential health risks due to release of toxic fumes and perfluorooctanoic acid (PFOA) (Sajid & Ilyas, 2017). **The PFAO is a chemical used in the production of PTFE. Aware of the health and environment risks involved, some industries in Pakistan are reported to have begun to replace PFAO**. PTFE manufacturing industries, if left unregulated, can release industrial affluent and contamination water bodies.

[1] Countries of cookware: Bangladesh, India, Nepal, Philippines, Tanzania, Viet Nam, Indonesia, Kenya, Ivory Coast and Guatemala

Over time, when large amounts of these substances enter our bodies, they can cause many negative health impacts, such as hormone disruption, immune system dysfunction, developmental delays, and even cancer. These nonstick pans are also made from Teflon, which is made from perfluorooctanoic acid (PFOA), and this is linked with kidney and liver problems. When these nonstick coatings peel off due to high temperature or scratch, they will become even more harmful as the chances of PFAS and PFOA entering our mouth increase and this nonstick coating also degrades into the environment by releasing metals while washing. Teflon or PTFE being cheaper than ceramic coating is preferred by many manufactures. For Teflon coating only Teflon spray technology is required, whereas for ceramic coating separate machinery is needed.

2.4 Policy Recommendations

a) The general strategy to reduce emissions include higher use of recycled aluminum, more clean energy use and shifting from natural gas operated furnaces to electricity-operated furnaces.

b) As the technological upgradation and energy management strategies are readily available in the sector, the Ministry of Industries & Production, along with the provincial government and other agencies is proposed to formulate National Mission for proper recycling of Aluminium.

c) As the ambient air pollution and waste from the sector are the major factory-based environmental problems associated with this sector, the government needs to incentivize the adoption of air purifying technologies in the industrial units.

d) The use of PFAS/Teflon as coating for non-stick pans needs to be phased out through an SRO directive to avoid a possible EU ban on PFAS so that the exports are not hit by the possible ban.

e) The alternative coatings such as ceramic coating are proposed to be incentivized.

f) A coherent and comprehensive and upgraded regulatory regime should accompany the 3 year transition period with clearly defined and disseminated standards.

2.4.1. Roadmap for the modernization cum greening

For the current study, we engaged the faculty of the University of Engineering and Technology, Lahore to prepare, in close consultation with the selected manufacturers, a technological roadmap for the modernization of the Aluminum Kitchenware Manufacturing, given below, making it Lean and Green, while giving a sense of costs, if large scale traditional manufacturers transition to modern technology and practices.

Processing Method	***Current Practices***	***Green Lean Interventions***	***Requirements***	***Estimated Cost (PKR)***
Raw Material Processing (Melting)	Ingots and scrap metal are melted in crucibles to form billets.	Introduce efficient melting furnaces, use renewable energy sources, implement real-time temperature monitoring.	Upgrade to high-efficiency melting furnaces, adopt real-time monitoring systems, introduce	10–15 million per furnace

			automated material handling.	
Rolling (Hot & Cold)	Manual labor-intensive rolling with outdated machines, high energy consumption, and maintenance requirements.	Introduce semi-automatic or fully automatic rolling mills, upgrade machines for energy efficiency, and optimize rolling schedules.	Invest in semi-automatic or automatic rolling mills and optimize rolling schedules.	25 million for semi-automatic rolling mills
Shearing and Blanking	Manual shearing and blanking in separate steps, resulting in 40% material wastage.	Introduce integrated shearing and blanking systems, automate the process, and improve metal recovery and recycling.	Upgrade to integrated shearing and blanking machines, implement waste recycling and reuse mechanisms.	15 million for an advanced circle assembly line
Deep Drawing / Metal Spinning	Hydraulic presses and manual spindle lathes used, leading to high material wastage and labor dependency.	Upgrade to modern hydraulic presses, use single-draw and cut technology, and explore die-casting for direct shaping.	Invest in hydraulic presses with automated features and introduce die-casting technology.	10 million for single-die hydraulic press, 30 million for die-casting machines
Surface Finishing (Coating, Anodizing, Sanding)	Manual sanding and emery paper processes requiring skilled labor, inefficient anodizing tanks, and energy-intensive conveyor ovens.	Deploy automatic sanding machines, install automated anodizing tanks, upgrade to energy-efficient conveyor ovens, encourage local PTFE coating manufacturing.	Invest in automatic sanding machines and anodizing tanks, install energy-efficient conveyor ovens, develop local PTFE coating manufacturing.	1 million for automatic sanding machine, 2.5 million for automated anodizing tank, 7.5 million for conveyor oven
Washing & Cleansing	Manual washing with water and dishwashing liquids, no automation, leading to high labor costs.	Introduce automatic washing lines to improve efficiency and reduce water consumption.	Invest in automated washing systems.	6 million for a washing assembly line
Fastening & Packaging	Manual riveting, screwing, and spot welding for handle attachment,	Introduce automatic feeding machines for rivets and screws, transition to die-casting methods for integrated fastening.	Install automatic feeding machines and transition to die-casting methods.	1.5 million for automatic feeders

with no automation.			

3. Plastic Kitchenware

In kitchenware, a good number of our food utensils are made up of plastics, which includes the items such as cutlery, utensils, storage containers, cutting boards, trays, serving platters and plastic wraps. Each of these plastic products is made up of different types of plastic like PET or PETE (Polyethylene Terephthalate Ethylene), HDPE (High-density polyethylene), PVC (Polyvinyl chloride), LDPE (Low-density polyethylene), PP (Polypropylene) and PS (Polystyrene). Many of these are hazardous for the environment as they are not biodegradable. Moreover, these plastic utensils are of different colors which degrade differently with certain colors becoming brittle and fragmenting over time, turning into microplastics that invade our ecosystems and even enter the human body. The plastic utensils melt and become brittle rather regularly due to negligence too producing microplastics.

3.1. Current Trends and Situation

Pakistan both imports and exports tableware and kitchenware made of plastic decreases. In 2019, Pakistan imported 957,864 kg of plastic by spending $2,258.49K, and its imports have gradually decreased as, in 2023, it imported 165,690 kg of plastic tableware and kitchenware for $1,064.58K. The export of plastic kitchenware and tableware in Pakistan shows that in the last five years Pakistan exports peaked in 2021 that is 639,825 kg and then the export quantity decreases in 2022 and 2023.

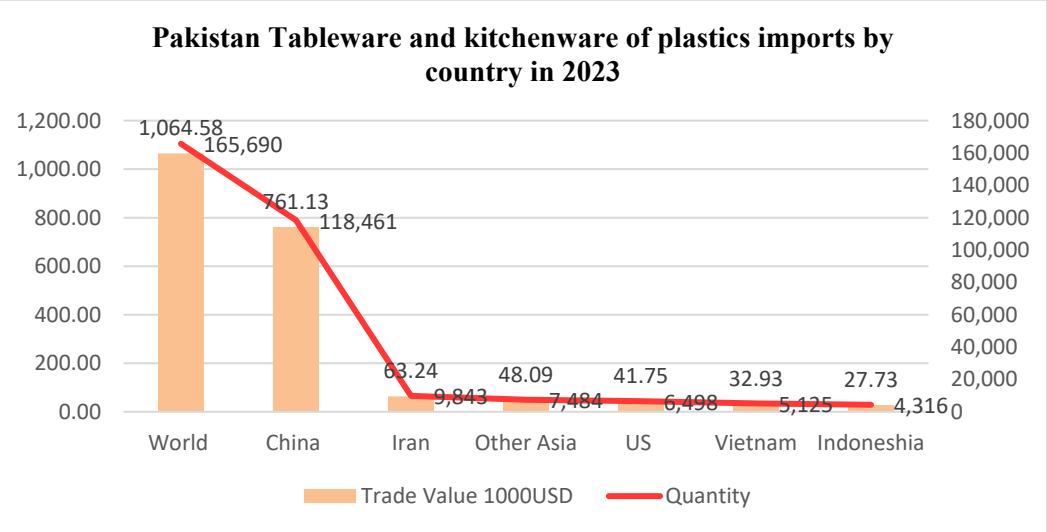


Figure 5

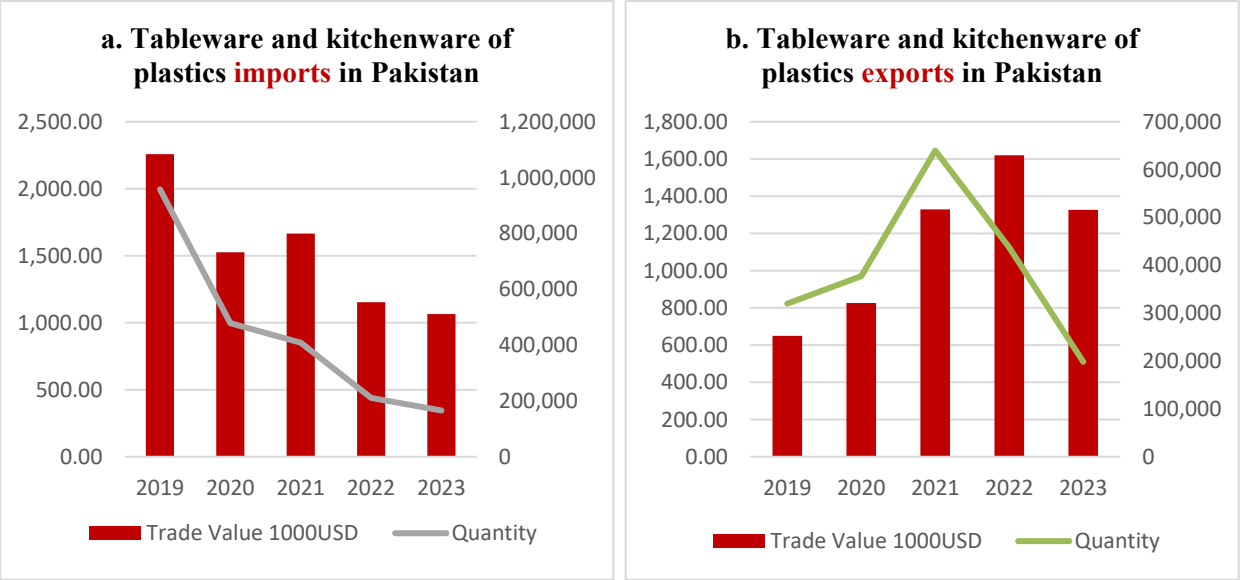
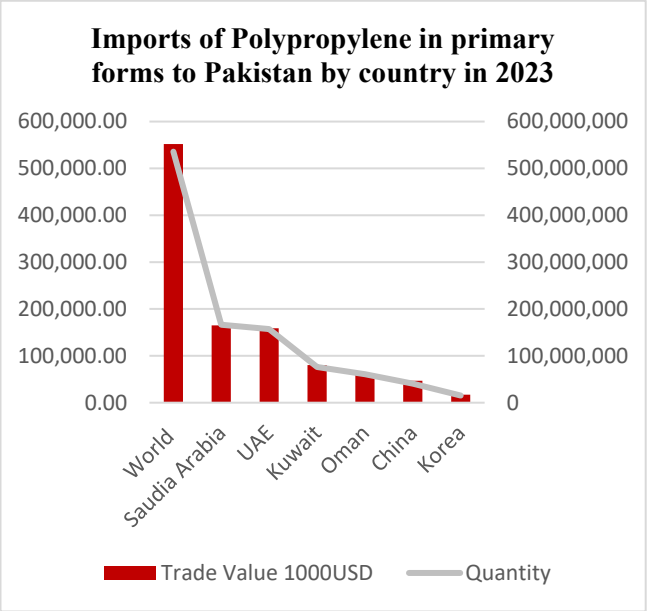


Figure 6

Plastic cutlery is being used in large quantities in households and restaurants alike. Plastic cutlery is commonly made from Thermoplastics polypropylene (PP) and polystyrene (PS). Plastic cutlery like knives, spoons, forks, plates consist of a variety of raw materials, but the huge amount of primary material used in these single use plastic utensils are non-renewable. Environmental Science & Technology found that polystyrene creates more soot and releases more harmful chemicals called polycyclic aromatic hydrocarbons (PAH) compared to polypropylene. Moreover, plastic cutlery falls in the category of single-use plastic. In 2019, the Ocean Conservancy reported that, “plastic cutlery was one of the top 10 items collected on beaches” (Ocean Conservancy, 2020).

Plastic cutlery usually consists with two types of petrochemicals Polypropylene (PP) and Polystyrene (PS). Both are petroleum-based. Pakistan has no primary petrochemical production facility and imports crude in large quantities. Pakistan’s petrochemical refining industry produces Polystyrene (PS).

According to WITS, Pakistan in 2023 overall imported 535,714,000Kg of polypropylene while out of this pakistan imports the majority of the polypropylene from Saudia Arabia which is 164,851.93Kg. While the rest of the Polypropylene in primary forms imported from UAE, Kuwait,Oman, China and Korea.



Source Raw Material	***Polypropylene***	***Polystyrene***
Polymer type	Thermoplastic polymer	Synthetic polymer
Production	Imported	Produced in Pakistan
Properties	Flexible, less rigid, more durable	Less flexible, more rigid, easily breakable
Relative cost of production	High	Less
Recycling	Recyclable	Rarely recyclable

Figure 7

The high quantities of polypropylene imported into Pakistan are indicative of the demand for polypropylene in the country. According to WITS, there is overall an increase in quantity imported into Pakistan from 2019 to 2023.

3.2. Policy Landscape

The use, production and retail of plastic cutlery and crockery is regulated under the following legislations:

- Federal Government: Single-use Plastics (Prohibition) Regulations, 2023
- Punjab Government: Plastic Management Strategy, Punjab 2023; Punjab Single-Use Plastic Production and Consumption Act 2023

The regulations need to be complemented with incentives and awareness of environment friendly alternatives such as something as simple as banana leaf tableware and cutlery.

3.3. Diagnostic Analysis

First, raw materials arrive at factories in the form of pellets. These pellets are thermoplastic materials. Injection molding is the method used to shape these thermoplastics into products like plastic cutlery or containers. The thermoplastic process occurs when the plastic pellets are heated in the injection molding machine until they melt and become soft. Once melted, the material is injected into a mold, where it takes the shape of the desired product. In Pakistan, this is typically done using machines like injection molding machines.

The plastic injection molding process starts by sending the plastic material and any needed additives into the heating and injection system of the machine. This process also generates environmental emissions inside and outside the plant. Moreover, various kinds of chemicals like mold protector agents, lubricants, degreasers, are also used during the molding process. These chemicals release a lot of harmful fumes if the amount of chemicals is not properly managed. When plastics break down due to heat it can release gases and tiny particles into the air, they can also release harmful chemicals that can cause cancer or breathing problems.

The main step that contributes more pollutant to the environment in the process of manufacturing plastic cutlery is the injection molding process. According to a recent Study, the injecting molding process of plastic cutlery caused the most environmental harm because it uses a lot of energy than any other manufacturing processes. Due to the huge price differential between the new and used Injection Molding Machines, most of the machines are imported second hand. The most impacted areas during the molding process is Global warming and damage to land ecosystem with 11.8kg of CO_2 and 12.0 kg of 1,4-DCB respectively (Aqib et al., 2024).

- Industrial Waste: During the molding process, the common waste material produced is plastic sprues. These Plastic sprues are basically the leftover pieces of plastic that remain after the process is finished. However, these leftover spruces can be collected, melted down, and turned into recyclable plastic and used again in the injection molding process. The manufacturing process also generates a large quantity of plastic scrap. These extra scrap and small pieces that can't be reused and the leftover thermoset plastic in the mold thrown away as regular waste into the landfills and take hundreds of years to disintegrate and releasing harmful chemicals into the environment.

- Energy consumption: Injection molding machines consume a lot of energy and contributes to air pollution, during the injection molding process. The energy required to produce per kilogram of plastic during the injection molding process is between 4 and 5 kWh (Huang et al., 2024). According to a study, the polymers are heated to temperatures between 150°C and 450°C for the production of plastic products (Guillemot et al., 2017). While the processing temperature of polypropylene and polystyrene is 180°C and 180–200°C respectively (Unwin., 2013). The injection molding process involves heating the plastic material to around 200°C. The mold where the plastic is shaped is kept at a temperature between 60-80°C while the plastic is injected into the mold at a temperature of 170-220°C, under pressure ranging from 60-150 MPa (Tang, 2022).

- GHG emission: In molding shops, toxic VOC emissions are released due to thermal process. The production of these emission increases and even releases more harmful emissions if the plastic overheated. Among the melting of polystyrene [PS] and polypropylene, PS creates more environmental pollution. Beside this during the injecting molding process styrene vapor can be formed if the Polystyrene is heated beyond its safe processing temperature. One kilogram of injection-molded polypropylene (PP) releases about 2.7 kilograms of CO2e and it produces about 9.3 million metric tons of greenhouse gases each year (Nicholson et al., 2021).

- Social compliance: In the workplace employees can be exposed to chemicals through the skin like when they touch substances or by inhaling dust and gases that are released during the thermal processing. Moreover, the workers in thermoplastic process can be exposed to harmful chemicals like during drilling, cutting, sanding or welding, due to overheat of materials. Like due to overheat of PS, it releases styrene molecules which can potentially impact the human nervous and immune systems and is also known as carcinogen. Due to prolonged or high concentration exposure it poses a health threat to workers.

Specifically, the manufacturing of plastic cutlery involves the use of high temperatures to mold plastic, which can pose a risk of burns and other heat-related injuries. Till date, there are few studies on the social compliance in the plastic cutlery sector specifically, but according to one of the Pakistani studies in plastic industries by Ahmed et al., 2018, 65.85% of the workers said that they were aware that there were hazardous chemicals, 70.25% agree that there was excess noise, and 25.35% agreed that they were working at a hazardous place.

3.3.1. Plastic Waste and Recycling

Approximately 49.6 million tons of solid waste is produced in Pakistan annually out of this 9% is of plastic including of single-use items like bags, packaging materials and cutlery (Naeem, 2024) Worldwide, Pakistan ranks sixth among the largest plastic waste generators while third in Asia (Naeem 2024). Plastic cutlery due to its non-biodegradable, ends up in landfills and degrades slowly and releases harmful chemicals into the environment, due to complex intermolecular bonds. These plastics can break into smaller pieces but they do not biodegrade naturally because of their high stability (Environmental Investigation Agency, 2016). Moreover, due to its light weight, there are chances that these end up in marine life or floating on the water surface, harming marine life by being swallowed.

Burning, as an option for waste disposal along with other waste, is also a hazardous as burning the plastic releases toxic substances such as dioxins, furans, and other chemical compounds, and these substances can be harmful to both human health and the environment.

After molding, the plastic is cooled and moved for packaging. To package plastic cutlery, usually cardboard or low-density polyethylene is used. The cardboard used is often coated with a shiny layer which makes recycling much more difficult. While the packaging through low-density polyethylene is also problematic as once this packaging ends up in landfills due to its low weight and they can cause hazard to animals and it decomposes and release carbon dioxide which contributes to climate change. According to a study, in Pakistani, most of the waste is generated from packaging.

Recycling of plastic remains a challenging option as, according to a Pakistani study, recycling industries use 3315 L of water per ton of plastic in which most of water is being wasted without treatment. Very few recyclers reuse most of the treated wastewater. Moreover, these recycling facilities also consume 172.5 kWh of energy per ton and observed an average temperature of 36.5°C, with large amount noise levels (Hashmi et al., 2023). We still lack Standard Operating Procedures for recycling industries of plastics to reduce energy consumption and unchecked use of high amount of water.

The cutlery plastic may contain leftover food which make them difficult to recycle and also most disposable cutlery like polystyrene plastics can't be recycled because recycling machines can mistake that disposable plastic as paper due to lightweight, creating problems with sorting and recycling.

3.4. Policy Recommendations

In order to control energy consumption, the manufacturers should use energy-efficient machines that consume less electricity and reduce overall energy costs. Most of the studies found that hybrid or electric machines can be more energy-efficient compared to hydraulic. The industry, with the help of government, can adopt energy efficient technology like in case of the manufacturing of melamine spoons, the best method showing high returns on investment, according to a recent study, is to use 50% solar energy and a double-cavity mold, resulting in the reduction of environmental impacts by over 50%. (Aqib et al., 2024).

There is a need to raise awareness about the environmental effects of disposable cutlery by using stricter regulations and push for more sustainable alternatives as the government tries to control the disposable cutlery market with rules that promote biodegradable and eco-friendly products. There is a need to continue raising awareness about the single-use plastic waste. We still do not have many alternatives for plastic disposable cutlery. There are discussions on promoting the use of edible cutlery, made from all-natural ingredients including the blend of rice, sorghum and millets, but the costs and customs remain an issue. (Iqbal et al., 2022).

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