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TECHNICAL PAPER

Use of disposable plastics and COVID-19 in Asia and the Pacific: Impact on plastic pollution in waterways and rivers

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Acronyms

AI	Artificial Intelligence
APEC	Asia Pacific Economic Cooperation
BAT	Best Available Technology
BAU	Business as Usual
CBWTF	Common Biomedical Waste Treatment Facility
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LCA	Life Cycle Assessment
MCO	Movement Control Order
MPW	Municipal Plastic Waste
MSW	Municipal Solid Waste
OFD	Online Food Delivery
PPE	Personal Protective Equipment
SUPP	Single-Use Plastic Products
SUPD	Single-Use Plastic Product Directive
UNEP	United Nations Environment Programme
UNWTO	United Nations World Tourism Organization
WHO	World Health Organization

Table of Content

Executive Summary

COVID-19 impacted global plastics production, consumption and raised concern over large scale plastic pollution. But the question is, how did a global health crisis have such an impact on a common consumable commodity like plastics? The answer to this lies in mobility restrictions, ban on social gathering and overall fear of catching the coronavirus that induced a change in lifestyles including that of our shopping behavior and personal hygiene practices. Dramatic increase in single-use plastic products (SUPP) packaging from the food sector such as plastics containers, cutlery, grocery bags, packaged and canned food products especially after the shopping channel shifted from in-shop purchases to takeaway/home delivery of grocery and food items is a display of the new relation between the pandemic and plastics. Increased use of single-use plastic-based personal protection equipment (PPE), mainly masks, gloves for medical applications as well as in the non-clinical setting is another manifestation of the relationship between COVID-19 and plastics. Overall, the COVID-19 pandemic has:

- changed sentiment over plastics, whereby the 'safety & hygiene' concerns fueled by consumer anxiety drove the consumption of disposable plastics, and unacceptance of reusables

- altered the landscape of the plastics value chain in terms of changed quantity and composition of plastics in our daily lives, waste streams, and disruptions in management of post-consumption plastic waste and recycling

- policy setbacks causing temporary suspension, withdrawal, delaying and derailing or reversal of enforcement of SUPP regulation and control

As a result, COVID-induced SUPP footprints increased more than the local waste management systems could handle, and with the plastics recycling disrupted, the pandemic risked the increased littering and leakage of COVID-waste. Masks, gloves, and food containers littered on streets and beaches and floating into rivers and waterways soon became a symbol of pandemic plastic pollution. The frequent presence of PPE items (mask and gloves) in the clean-ups made them one of the top categories of beach litter for the first time. There is also a hint of disposable PPE items such as masks and gloves reported in the illegally shipped containers with other plastics waste in 2020/2021. Take-out items mainly plastic bags and wrappers, food containers and cutlery, plastic and glass bottles, and cans too are becoming the largest share of litter items collected from rivers and oceans.

One of the observations during the pandemic was the myths and misconceptions on reusable plastic products being less safe than single-use plastic products. This disinformation inflated the consumption of SUPP by consumers as well as influenced the policy setbacks. Despite the relaxation of the COVID restrictions, concerns over hygiene and safety have further strengthened. Changes in the etiquettes and operation in the travel, tourism, food servicing, food retailing services are likely to consume more SUPP and continue to mistrust reusables. Therefore, it is urgent to address the pandemic plastic pollution by rethinking and optimizing our current unsustainable plastic consumption and inefficiency and inadequacy in the existing waste management system through *education, innovation, and regulation* to *unpause* the interruption in plastics reuse and recycling during the pandemic.

- demystifying the myths by educating and raising awareness through evidence-based harmonized consumer information and encouraging embracing reuse and recycling

- innovating solutions to balance hygiene and sustainability through material and design innovation, circular supply chain logistics and business models, technological innovation in measuring, monitoring, and managing plastics waste from rivers and oceans

- accelerating existing policies to take more comprehensive attention and actions towards minimizing SUPP

It is time that the world, more so the Asia and the Pacific region, hears this warning bell that the COVID-19 has rung and addresses the plastics pollution issue more seriously with accelerated efforts to get on the track with SUPP reduction targets now than derailing those efforts waiting the pandemic gets over.

1. Context: COVID-19 pandemic and plastics

From the first onset of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), commonly known as COVID-19 on 31st December 2019 in Wuhan, globally there have been 196,553,009 confirmed cases, including 4,200,412 deaths, and a total of 3,839,816,037 vaccine doses administered as of 30 July 2021, according to the World Health Organization (WHO)[1]. Region-wise, there are 47.5 million COVID-19 cases in the Asia-Pacific countries[2].

The COVID-19, a global health crisis, caused about as much as a 40% increase in the volume of medical waste generated globally (IFC 2020). Positive effects of the pandemic on the environment, which was mainly observed in the form of a reduction in air pollution and Green House Gas (GHG) emissions have been short-lived. The initial respite for wildlife and ecological restoration due to restriction of movements soon saw a spike in deforestation, illegal logging, poaching, mining, among other increased environmental crimes, as likely outcomes of long-term lockdown and lowered forest monitoring systems (FAO, 2020; Gardener, 2020). Similarly, once the economic shut-down was lifted, local and international travel resumed, manufacturing bases ran their operation, things got back to the pre-COVID-19 situation.

1.1 Overview of evolving relationship with single-use plastic products before COVID-19

The first plastic 'Bakelite' was invented in 1910. Since then, our relationship with plastic has been evolving. It was from the 1950s that plastics production and consumption proliferated. The 'wonder material' is almost ubiquitous to the modern societies catering for the human needs of construction and building, automotive, electrical and electronics, industrial machinery, medical devices, textiles, and countless consumer products. Between 1950 and 2017, an estimated cumulative total of 9.2 billion tonnes of primary plastics has been produced (Geyer, 2020a). More than half (56%) is produced only after 2000 (Heinrich Böll Stiftung 2019). Geographically, Asia accounted for a whopping 51% of this global production. It is notable that globally, a significant quantity of plastic produced is intended for single use. An estimate from the Minderoo Foundation's Plastic Waste Makers Index (2021) shows a third of plastics produced every year is single-use plastic (Charles, Kimman and Saran, 2021), with 98% manufactured from fossil fuels (Geyer et al., 2017). The dominant use of single-use plastic is packaging (Ksenia et al., 2019). Packaging is responsible for 46% of the global total plastic waste in 2018 (Geyer, 2020b).

SUPP has become almost synonymous with the global plastic crisis. Most plastic products and packaging are thrown only after a single use and within a few minutes, but it lasts for years after its disposal in the environment. Plastic (retail) bag, for example, get used only once and becomes waste within 15 minutes of its consumption while it could remain in the environment for 20 years (PlasticOceans, 2020). In 2019, an estimated over 130 million metric tons of SUPP were discarded (Charles, Kimman and Saran, 2021) as shown in **Table 1-1**.

Table 1-1 Single-use plastic product categories thrown away (million metric tons) in 2019

SUPP category	Discarded
Food bottles	25
Retail bags	16
Food packaging	15
Sheet packaging	10
Film packaging	18
Trash bags	15
Non-food bottles	5
Industrial bags	3
Laminated packaging	3
Caps and closures	2
Cups and containers	1
Pharmaceuticals, cosmetics, and toiletries	1
Other polymers *(not in scope of this analysis[3])*	16
TOTAL	**130**

Source: Charles, Kimman, and Saran, 2021

[1] WHO Coronavirus (COVID-19) Dashboard. https://covid19.who.int/
[2] OCHA. Impact of the Crisis. https://interactive.unocha.org/data/ap-covid19-portal/impact-crisis.html
[3] The "in the scope of the Minderoo Foundation, 2021 analysis INCLUDES **five main polymers** that account for almost 90% of all single-use plastics: PP; HDPE; LDPE; LLDPE; and PET

According to the Minderoo Foundation's Plastic Waste Makers Index (2021), 20 polymer producers accounted for an estimated 55% of single-use plastic waste globally. 11 of the top 20 polymer producers are headquartered in Asia (5 in China), 4 in Europe, 3 in North America, 1 each in Latin America and in the Middle East. Four of them produce exclusively PET, a polymer which is mainly used to make bottles and other rigid plastics. Considering rigid plastics have higher rates of collection and recycling than lower-value, flexible plastics, these four companies are likely to generate less plastic pollution than others (Charles, Kimman and Saran, 2021).

Mismanagement of plastics leading to littering and leakage to the terrestrial and aquatic environment and its compounding threats to oceans, human health, and the economy has put plastic pollution as one of the pressing global environmental issues. There is not a place on this earth, from the deepest Mariana Trench to the highest peak Mount Everest, that do not have traces of plastic waste. The 2013 global flows of plastic packaging materials (WEF, 2016) showed an overwhelming 72% not recycled at all (40% is landfilled, and 32% leaks out of the collection system). Of the rest 28%, 14% is incinerated or energy is recovered. Another 14% is collected for recycling, of which, 4% is the process lost and only 2% is closed-loop recycling (recycling of plastics for same or similar quality applications), with 8% is cascaded recycling (recycling of plastics into other lower value applications). Each year, at least 8-12 million tonnes of plastics leak into the ocean. A study by the PEW Charitable Trusts and SystemIQ (2020) estimated an 11 million metric tons of plastic entered the ocean from land in 2016, and projects plastic flows into the ocean under the Business-as-Usual scenario (BAU) to nearly triple by 2040, to 29 million metric tons per year, which is equivalent to 50 kg of plastic per metre of coastline worldwide.

1.2 Impacts of COVID-19 on plastics value chain

The COVID-19 related lockdowns, decreased in global economic activities, trade restrictions, industry closures, declining production capacity due to workers' safety concern owing to the COVID-19 outbreak, as well as low crude-oil and other feedstock prices impacted global plastics production, distribution, consumption, and recycling. Demand for SUPP especially by essential sector (food packaging, medical, e-commerce packaging and personal protective equipment), skyrocketed while non-essential durable plastics (construction and automotive applications) suffered a dip. According to the Wood Mackenzie Chemicals analysis 2020, during COVID-19, PET polymer (used in packaging) saw the least decline, followed by polymers like LDPE/LLDPE, PP[4] and HDPE, which are used in most SUPP. These polymers suffered a low decline compared to polymers like PA66 and PVC that are used in durables in the transportation and building & construction sectors. **Figure 1-1** below depicts the impact of COVID-19 on entire plastics value chain.

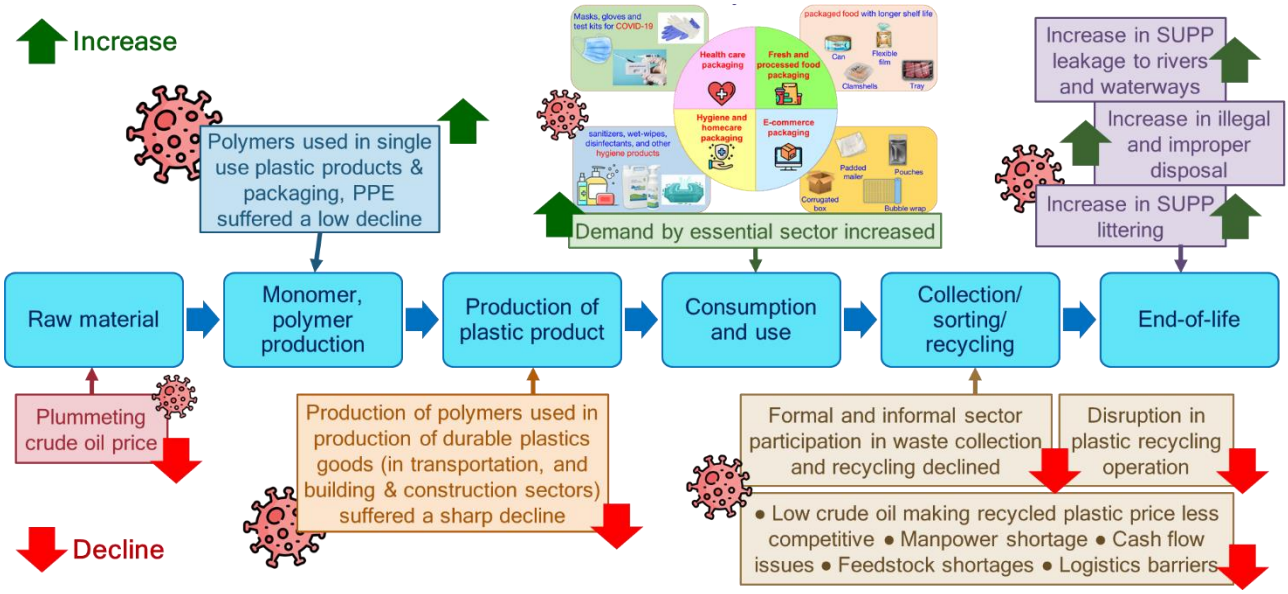


Figure 1-1 Impact of COVID-19 on plastics value chain

4 Polypropylene, a non-woven material that was largely used in making PPE.

Text Box 1-1 Impact of COVID-19 on plastics industry

Thailand:

According to the Krungsri Research on Thailand plastic industry outlook 2021-2023 (Krungsri Research, 2021), overall demand for plastic products contracted, as the major industrial consumers of plastics (e.g., auto assembly, electronics & electrical appliances, and construction) were badly hurt by the COVID-19 impact on the global economy in first half of 2020, but the pandemic fuelled the single-use items, especially medical devices, PPE, and food packaging. The year-on-year (YoY) plastic resin production declined by 2.8%. Exports of plastic resins also dropped by 7.3% YoY to 6.1 billion tonnes, however, the export value of plastic packaging rose 1.4% YoY. Similarly, the domestic sales volume of plastics products slipped by 0.3% (to 0.6 million tonnes), but demand for plastic bags increased because of a strong growth in food delivery services by 3.3% YoY. According to the Krungsri Research forecasts throughout 2021 to 2023, demand for plastic products will rise by an annual average of 2.0-3.0%, in line with the steady recovery of the global economy, and the output of plastic packaging is expected to expand by 0.0-1.0% annually.

Malaysia:

During the COVID-19 related movement control order (MCO) in Malaysia the operation of plastic industry in the country especially in the non-essential products sub-sectors were impacted. According to the Malaysian Plastic Manufacturing Association (MPMA)'s 2020 annual report, during the first (18-31 March 2020) and second (1-28 April 2020) phases of the MCO, only 40% of plastics companies were allowed to operate at 50% capacity to cater for the essential sectors, such as food, medical and personal protective equipment. Coming to the third phase of the MCO (from 29 April to 12 May 2020), though more companies were given approvals to operate, the average operating capacity reached only 60%. This is because plastic companies faced to supply chain disruption, manpower shortages and cash flow issues., hence affecting the overall turnover (MPMA, 2021).

Flexible Packaging is a sector that has seen an enormous demands during pandemic and the market is expected to grow in post-pandemic times too. According to the ResearchAndmarkets.com, 2021, the global flexible plastic packaging market size is projected to grow from US$160.8 billion in 2020 to US$ 200.5 billion by 2025, at a CAGR of 4.5% from 2020 to 2025. The growth in flexible plastic packaging market during the forecast period (2020-2025) is expected to be increased demand in end-use industries, such as food, beverage, cosmetic & personal care, and pharmaceutical, and acceleration of e-commerce activities, especially in the emerging economies. The **global medical plastics** market size during COVID-19 pandemic is also projected to grow from US$ 25.1 billion in 2020 to US$ 29.4 billion by 2021, at a CAGR of 17.2% in terms of value, between 2020 and 2021, which is approximately 10% higher than earlier pre-COVID growth projections (RESEARCH & MARKETS, 2020). Region wise, the market forecasts that Europe is expected to be the fastest-growing medical plastics market during the crisis period (30%), followed by Asia-Pacific (25%), South America (25%), North America (20%), and Middle East & Africa (10%). The **e-commerce plastic packaging market** is also expected to reach US$ 21.78 billion by 2026 (a jump from US$ 10.26 billion in 2020), according to the ResearchAndMarkets.com (2021) forecast.

1.3 COVID-19 and the changing relationships with plastics

COVID-19 has altered plastics production, consumption, and disposal patterns. More specifically, the pandemic has:

- **changed sentiment over plastic**, wherein 'convenience' in plastics consumption is accompanied by the strengthened 'safety & hygiene' concerns (fuelled by consumer anxiety) driving the increased use of disposable plastics, and unacceptance to reusables

- **altered the landscape of the plastics value chain in terms** of changed quantity and composition of plastics in the society and waste streams, and disrupted post-consumption plastic waste management and recycling

- **caused SUPP policy setbacks** such as temporary suspension, withdrawal, delaying and derailing or reversal of enforcement of national and sub-national (city/municipality) SUPP banning policy or policy promoting reuse

Convenience had powered SUPP consumption even before COVID-19, but the pandemic uniquely added a 'safety & hygiene' aspect to it. Demand for single-use plastic products and packaging skyrocketed during the pandemic, notably in food servicing and delivery and medical sectors. With usual coffee cups, food containers, plastic grocery bags, have entered the plastic-based personal protective equipment (PPE) – mask, gloves, face shield, gown, and hygiene and sanitizing products packed in plastic bottles into our daily routine. While there has been no evidence of the spreading of the coronavirus from the contaminated surface reported so far, it is the fear over virus transmission that an additional layer of (plastic) packaging and the preference for disposable plastics over reusables is being perceived as a safer option to reduce the risk of virus exposure. A surge of disposable plastics and plastic packaging waste in the municipal solid waste stream became evident.

The pandemic also disrupted regular waste collection and recycling activities by both the formal and informal sectors, causing increased illegal dumping, littering and leakage of plastics to the terrestrial and aquatic environment. COVID-19 thus has added complexity to the already complex plastics pollution issue. At the same time, it has also brought plastics into the centre of the pandemic discussion and the need for a fundamental rethinking to make our relationship with plastics more meaningful whilst maintaining a balance over hygiene and sustainability.

2. Changing landscape of single-use plastics during COVID-19 in key sectors

Impacts of COVID-19 has been felt across the entire plastic value chain: from the manufacturing of virgin plastics to consumption, handling, treatment, recycling, and disposal. More so, the plastics and plastic packaging waste landscape changed distinctively for the e-commerce, food servicing, health care sectors. Globally, municipal plastic waste (MPW) made 12% of total municipal solid waste (MSW) composition (Kaza et al. 2018). This pre-COVID-19 figure has every likelihood to inflate during the pandemic. A trend has also been observed that due to lockdown and mobility restriction, temporary shutdown of markets, malls and tourism activities, plastics from residential sources have seen a hike, while wastes from commercial and institutional sources saw a decline. Similarly, the use of PPE in a non-clinical setting has blurred the distinct line of municipal and medical plastic waste.

2.1 COVID-19 and disposable plastics in the food servicing sector

The food servicing sector includes business operations as in 1) **dine-in** (full-service restaurants/or quick-service/takeaway/takeout) outlets with sale of food and beverages that are prepared for immediate consumption, 2) **food retail** grocery stores, supermarkets selling food ingredients (mostly uncooked), and 3) **online food delivery** (OFD) platforms offering both ready meals and/or grocery (e-grocery) transported to the customers who place orders via internet.

Plastic is quite literally 'the skin of commerce' (Hawkins, 2018), more so, of the food and beverage products. Food and Beverage is the largest end-use sector of consumer packaging, and it accounted for approximately 50% (Feber, Nordigården, and Varanasi 2020). Single-use plastic packaging is ubiquitous to both food retail and takeaway services. Both flexible and rigid plastics are preferred packaging material for food service sector. **Food retailing** uses more of flexible plastic packaging, including films, wraps, plastic seals (for deli meat, cheese), zipper lock pouches (for frozen fruits), crinkly wrappers, bags and pouches (bags for chips, energy bars), woven and net plastic bags (nettings for onions, oranges, woven plastic bags for dry goods like rice), tear notches, peel-off lids, hang hole features, and microwavable pouches, and non-food protective packaging (like air packets, shipping envelopes, bubble wraps etc.). Food products in smaller packaging increases the packaging per food unit. About one-third of all food packaging is produced for short time use only (Koelmans et al. 2014).

Text Box 2-1 Single-use plastic packaging in U.K. supermarkets

Food retail activities, the supermarkets, grocery stores are full of single-use plastics in the form of individually packaged/ wrapped food, fruit and vegetable items, and grocery bags. In the United Kingdom, supermarkets are responsible for putting 59 billion pieces of single-use plastic packaging annually - equivalent to 2,000 pieces for each household. This is in addition to the 1.1 billion single-use bags, 958 million bags for life and 1.2 billion produce bags (Environmental Investigation Agency and Greenpeace, 2019).

Food servicing and food delivery sectors often use Rigid plastic packaging (PE, PET, PP, PVC, EPS, PS, Bioplastics) that makes single-use products like bottles and jars, trays, tubs, cups, pots, plastic lids, blister, and clamshell packs.

Text Box 2-2 Facts about SUPP in food servicing (takeaway and online food delivery sector)

- 65 million plastic meal containers and thousands of tonnes of plastic spoons and bags were discarded every single day in China in 2017 (Chu, Liu and Salvo 2020). Other statistics by (Wang, Ma and Zhang 2017) shows 20 million takeaway orders are placed per day across the three online food delivery platforms in China, which uses 7.3 billion single-use plastic tableware sets per year. According to Liu, et al (2020), urban food delivery service packaging in Jing-Jin-Ji region, China accounted for 15.7% of the total urban waste generated. Of the waste generated by 100 table sets of online food delivery, largest potion, 1.78 kg was mixed plastic waste, followed by 0.46 kg of waste chopsticks and 0.29 kg of paperboard waste.
- Singapore used about 1.76 billion plastic items each year (in 2018), out of which, 473 million plastics were disposable items like takeaway containers, according to a study commissioned by the Singapore Environment Council (SEC, 2018).
- It is estimated that in Thailand 700,000 tonnes of polystyrene is used for food containers per year, 1.72 million tonnes of plastic cups and straws, together with 1.17 million tonnes of plastic bags (Wipatayotin 2020)
- For dine-in service versus takeaway/OFD, the latter is SUP-intensive. OFD uses 8 times more plastic (54 g/meal) than dine-in service (6.6 g/meal), in a variety of forms including cutlery/ chopstick sleeves, condiment containers, or bottles (Chu, Liu and Salvo 2020)

COVID-19 caused a shift in food servicing operation, shopping pattern, market growth and packaging waste. Since traditional brick and mortar shops were closed, supermarkets shut, dine-in services suspended, due to the fear of catching the virus, or simply because of "stay-home" measures encouraged or enforced, takeaway, online food delivery and e-grocery became the preferred medium than the traditional in-shop purchasing globally. An estimate by the StockApps.com (Kranjec 2021) expects the global online food delivery market to hit US$ 151.5 billion in revenue and 1.6 billion users in 2021, a 10% jump year-over-year. Over one third of the online population globally said they've purchased a grocery item since the start of the pandemic in September 2020 (Gorman 2020). There is a significant addition of 'new user/consumers' who ordered food, grocery online for the first time because of the pandemic situation. There are also new e-commerce platforms expanding fresh produce category and investing in logistics to assure these essentials get to the consumers. In April 2020, Lazada expanded their fresh produce category to Malaysia, Vietnam, and Indonesia, before pandemic the grocery service was available only in Singapore, Thailand and the Philippines (New Straits Times, 2020). Amazon's Whole Food Markets increased grocery delivery capacity by more than 160% and tripled grocery pickup locations during the second quarter meet the surge in demand from about 80 stores to more than 150, with further extensions over time being likely (Davis 2020).

Region-wise, in Asia and the Pacific, COVID-19 was less of a driver for new consumers to join online shopping as a large sect of the population was already using online grocery services before the pandemic. Nevertheless, according to the Google, Temasek and Bain (2020), there was a shift in buying behaviour due to COVID-19 lockdowns across South-East Asia (SEA), where consumers moved online for food delivery and groceries more than before the COVID-19 lockdown by 34% and 33% respectively. **Table 2-1** below illustrates the changes in food and grocery shopping in selected countries during COVID-19. Such increase in OFD and e-grocery during the pandemic has significantly added SUP waste from households.

Table 2-1 Increase in online food delivery (OFD) and e-grocery during COVID-19 in Asia and the Pacific

Country	OFD growth	e-grocery growth
Cambodia	COVID-19 has accelerated the adoption of food and grocery delivery apps and fuelling food e-commerce activities in Cambodia. FoodPanda, KiwiGO, Nham24, Muuve, E-gate, Grab are popular online food delivery platforms.	• The Ministry of Commerce, Cambodia on April 21 launched an online marketplace https://shop.moc.gov.kh/ to sell essential groceries to people during the coronavirus lockdown. • Grocerdel, which delivers fresh farm produce and locally made products in the capital Phnom Penh as its order skyrocket by over 180% since COVID-19 struck, forcing the start-up to increase its staff by

Country	OFD growth	e-grocery growth
		50% to cope with the spike in demand (UNCTAD, 22 June 2020)
Lao PDR	The main food delivery companies in Lao PDR - Go Teddy and FoodPanda reported that the number of online orders increased from 100-200 to 1,200-2,000 a day in less than two months (during the March-May 2020 lockdown) (UNDP Lao PDR, 2021)	Comparatively slow adoption of food e-commerce than other ASEAN member states, Lao PDR is opening up for e-grocery during COVID-19 pandemic. • LOCA GRO (https://www.locagro.la/en/), one of Lao's ecommerce services, is launched by the creators of Laos' first ride-sharing app, LOCA, as an on-demand grocery shopping application. As of 4 May 2020, the service includes groceries and household products from popular retailers in Vientiane Capital. • On 16 August 2021, FoodPanda announced the launch of its first Pandamart - FoodPanda's grocery cloud store purposely built for deliveries only, with no walk-in retail services for Laos where consumers can access to more than 2,000 grocery and household products, delivered within 25 minutes. FoodPanda aims to expand its pandamart to 4 locations in Vientiane in 2021 and by 2022 to more provinces (The Laotian Times, 2021)
Myanmar	While Myanmar's retail scene continues to be dominated by Traditional Trade channels (and in-store shopping from the retail stores in close proximity), this appears to be changing as the demand for these services skyrocketed across the board during the pandemic (Deloitte, 2021).	• CityMart, Myanmar's largest retail group, offers direct delivery and physical store pickup services for online purchase through its "City Mall" platform • Convenience store chain G&G partnered with Myanmar's largest shopping platform, Shop.com.mm, to offer its products
Thailand	• Food delivery service LINEMan's order grew 300% from the beginning of Bangkok's lockdown in March through the end of April 2020 • Food Panda's order grew 50% in March as compared to February's order (Tanakasempipat, 2020)	• The first half of 2020 saw a website traffic of online general department stores increased by up to 18% in Thailand, Indonesia, and Malaysia compared to the second half of 2019 (Chern, 2020) • Store-based retail sales growth decreased by -10.8% in 2020, according to Euromonitor Passport database (Ho, 2021)
Vietnam	• As a result of the pandemic, more than 50% of Vietnamese consumers have reduced their frequency of visits to supermarkets, grocery stores, and wet markets, while 25% of them have increased their online shopping (NielsenIQ, 2020)	• Grab launched its grocery e-commerce platform, GrabMart, in Vietnam on 23 March 2020. In its second week, orders surged by 91% over the previous week (Thong, 2020) • Store-based retail sales growth decreased by the least among ASEA countries, only by 0.03% in 2020, according to Euromonitor Passport database (Ho, 2021)
India	• During the 21-day lockdown announced on 25 March 2020, order volumes of online food aggregators like Swiggy and Zomato plummeted by 60-70%. However, with phase-wise reopen, the online food delivery business is recovering (Tandon and Bhalla, 20 June 2020)	• The e-grocers, Amazon and Flipkart, BigBasket and Grofers, reported a two- to threefold increase in orders. • Food-delivery platform Zomato also launched a new business-to-business grocery vertical called Hyperpure to focus on supplying farm produce to restaurant partners. Similarly, Swiggy, also re-deployed its food delivery workforce as grocery delivery and concierge services. • For food aggregators, like Swiggy and Zomato, grocery delivery accounts for only 20% of their business, with almost 80% of their operations and revenues focussed on food deliveries. (Tandon and Bhalla, 20 June 2020)
Sri Lanka	• The government of Sri Lanka and Uber Eats have joined forces to deliver everyday essential food items supplies to households in Colombo and the suburbs. • Social media is becoming a preferred platform to continue commercial activities. Established online platforms such as PickMe and other vendors have started connecting to their customers directly via	• Nearly 53% of the COVID-19 e-commerce survey respondents claimed that they would still opt for online shopping in the months immediately following the lockdown; gas, non-perishable essentials and home and personal care topped the list of products that consumers hope to purchase online post-lockdown (Watukara, 2021).

Country	OFD growth	e-grocery growth
	platforms such as WhatsApp and Facebook (Talking Economics, 4 May 2020).	
Singapore	• 73% growth in online food delivery during the eight-week lockdown/circuit-breaker period between 7 April 7 to 1 June 2020 (Lay, 2020) • GrabFood Singapore saw a 60% increase in order (Abdullah, 2020)	• online grocery sales in Singapore jumped four times from early April as reported by Alibaba-backed Lazada (Choudhury, 2020) • Store-based retail sales growth decreased by -17.8% in 2020, according to Euromonitor Passport database (Ho, 2021)
Indonesia	4% increase in GrabFood Indonesia's delivery orders (Arbi, 2020)	Store-based retail sales growth decreased by -18.3% in 2020, according to Euromonitor Passport database (Ho, 2021)
Philippines	According to a survey conducted by Rakuten Insight in the Philippines, 80% of the respondents aged 45 to 54 stated ordering more through food delivery apps due to the imposed closure of all restaurants during the COVID-19 pandemic as of June 2020 (Statista, 2021)	Store-based retail sales growth decreased by -9.8% in 2020, according to Euromonitor Passport database (Ho, 2021)
Malaysia	Before the Covid-19 pandemic, online food deliveries in Malaysia were already popular within urban areas. The OFD industry grew with the introduction of the movement control order (MCO), where more Malaysian food businesses including cloud kitchens started offering online food delivery. According to a survey by Rakuten Insight, in 2021, Malaysia observed a 13% increase in shopping frequency at online shopping sites, and 11% increase in using food delivery services, compared to 2020.	Store-based retail sales growth decreased by -19.6% in 2020, according to Euromonitor Passport database (Ho, 2021)
China	Meituan delivered 40 million meal orders on a single day in August (Tam and Huang, 2020)	• Sales of food products via e-commerce saw an accumulated increase of 36% from Jan to Apr 2020 relative to 2019 (OECD, 2020) • From 24 January to 2 February 2020, the transaction volume of JD Daojia, an online grocery store owned by JD.com, China's second-largest e-commerce firm, increased by 374% year on year. • Missfresh, a Beijing-based online fresh food e-commerce website, saw trading volume rise by 321% from 24 January to 28 January compared to the previous year (Zhang, 2021)
Taiwan	Uber Eats and Food Panda's order increased by 20%–30% during the pandemic. The Ubox's sales increased by 5.7% per additional case of COVID-19, their customers grew 16% in a typical week during the COVID-19 period (Chang and Meyerhoefer 2020)	Based on a survey of 801 consumers in March 2020, 21% of survey respondents claimed to have shifted purchases online from retail outlets due to COVID-19, whereas 18% of respondents did the same for beverage purchases (Chen 2020).
Republic of Korea	• According to Statistics Korea, the pandemic contributed a 73.6% on-year increase in the online food delivery, with a cumulative turnover in the January-July 2020 period reaching 8.66 trillion won ($7.78 billion) (Sarah, 2020). • The number of food deliveries in 2020 skyrocketed 75.1% from a year earlier, and the number of overall deliveries surged 19.8% on-year, according to the Ministry of Environment (Jun-tae, 2021).	• A reported 92.5% increase in online food purchases in South Korea in 2020 as compared to 2019. • e-commerce transaction value rose by 15.8% between July 2019 and July 2020. Significant increases were observed for food services (66.3%), household goods (48%) and food and beverages (46.7%), (Mu- Hyun 2020)
Australia	Takeaways and food delivery had a good market penetration, even before the pandemic. The food delivery service industry grew by $2 billion in 2020 as a result of COVID-19 (Goodman Fielder, 2021)	Food retailing rose 1.6% in January 2021 (Australian Bureau of Statistics, 2021)
Japan	According to a survey conducted by Tokyo-based Ai-land in mid-July 2020 on 454 respondents, the number of online food purchases made per month increased from before the spread of the virus by three to four times for 43% of respondents, by one to two times for 33%, and by five to six times for 16% (Loew, 2020)	Due to COVID-19 and prolonged raining season, according to the data released by the Japan Department Stores Association, Japan's department (in) store sales dropped 20.3% in July 2020 as compared to 2019. Food purchases at department stores also dropped, by 11.5%. In Japan, the basement of department stores is usually devoted to food (Loew, 2020)

In addition to the increase food e-commerce, few significant changes in shopping behaviour and perception of food safety listed below are responsible for the increased single-use plastic products & packaging waste from the food servicing sector during the pandemic.

- **Stocking pandemic pantry**: COVID-19 induced panic buying a hoarding of food with long shelf-life increasing the demand for packaged food, canned food and frozen food than fresh produce, hence SUP packaging from food retailing. In a survey from 23 countries[5], 45%–48% of the respondents observed increased consumption of packed food, fresh food, and food delivery during the pandemic, and 53% increase in plastics packaging in household waste reported (Filho et al. 2021)

- **Increased food e-commerce**: The mobility restriction, closure of shops automatically increased the home deliveries (e-grocery) of essential item like food and grocery and likely increase in the volume of plastics used in e-commerce packaging. Similarly, increased takeaway and home deliveries of cooked food/ready meal led to an increased consumption of disposable plastic tableware. At a minimum, one delivery order creates on average four plastic items (including food containers, cutlery, carry bags, and container or pouches for condiments). According to the Sunday Times, UK., cited in Speciality Food Magazine (21 May 2021), an order of 15 takeaways were served with 103 individual pieces of plastic packaging, even after declining extra cutlery.

- **Shift in perception of food safety pushed back the sustainability** in the food packaging sector: Despite any evidence of food packaging being associated with transmission of the coronavirus, safety concerns related to COVID-19 led to a preference of disposable plastics than reusables, and even preferring previously loose food/goods to use plastic packaging. In a survey with 1,000 adults in the United States, over one-third (42%) reported that they have purchased more packaged foods in April 2020 due to COVID-19 fear (IFIC, 2020). The pandemic pushed back food retailers and food servicing businesses to deprioritize sustainability aspects by suspending to accept (bring your own/BYO) reusable bags and containers and refill options. Starbucks U.S. temporary suspended BYO scheme, so did Koi a bubble tea maker in Singapore. Heightened awareness on hygiene and changes in dining etiquette in the 'new-normal' scenario has made restaurants reportedly replacing silverware with disposables, adding individually packed wet wipes and other sanitizing products per customer, and using plastic dividing screen across tables, all adding up the disposable plastic waste consumption.

The COVID-19 pandemic has caused a dramatic increase in single-use plastic packaging waste from the food servicing and food retailing sector (**Table 2-2**). In addition to the disposable food containers and cutlery, grocery bags and packaged food, fruits, and vegetables, operating dine-ins services in the 'new normal' context meant addition of new kinds of disposable plastics such as dividing screen across tables, replacing silverware with disposables, adding individually packed wet wipes and other sanitizing products per customer, and wait staff using gloves.

Table 2-2 Increase in SUPP from food servicing sector during COVID-19

Country	Municipal plastic waste from food retailing and servicing sector during COVID-19
Thailand	• A report by the Environmental Research Institute, Chulalongkorn University (ERIC) showed that between January and April 2020, plastic waste increased by 62% (from 5,500 t/d to 6.300 t/d) from the same period in 2019. Majority of increase in of non-recyclable SUP bags, Styrofoam boxes, plastic bottle, and cups. ERIC also predicts that the amount of plastic waste from online food delivery businesses will increase to over 2,325–6,395 billion pieces per year in the next 4 years (2025). (ERIC, 2021) • The COVID situation increased online shopping and delivery to 300% (Promchertoo, 2020).
Bangkok	A jump from 2,120 t/d to 3,440 t/d Due to significant increase in food delivery and online shopping, during Jan – Apr 2020, Bangkok's plastic waste soared 62% in volume in April 2020 (Promchertoo, 2020)
Singapore	Singapore households generated additional 1,334 tonnes of plastic waste during 8-week circuit breaker period (April 7 to June 1, 2020), mainly due to takeaway, online food delivery and online grocery - disposable cutlery and containers, (NUS, 2020)
Hong Kong	• A study by local NGO, Greener's Action showed that single-use plastic volume from food takeaway was 2.2 times more in April 2020 compared to 2019 (CTGN, 2020)

[5] Portugal, Italy, Germany, Brazil, Estonia, United States, Australia, Canada, Singapore, United Kingdom, Denmark, Spain, Poland, Finland, Bangladesh, Argentina, Chile, Ireland, New Zealand, Japan, Malaysia, Indonesia, and Vietnam)

Country	Municipal plastic waste from food retailing and servicing sector during COVID-19
	• Estimated 101 million pieces of disposable cutlery and plastic bags were disposed of every week in April 2020, which is considered to be more than 200% increase comparative to 2019 (South China Morning Post, 7 Aug 2020).
Malaysia	• Malaysia used 148,000 tonnes of plastic packaging for food in 2020 alone (Yeo, 2021) • According to a survey designed and conducted by Penang Green Council from 4th June to 31st July 2020, reveal an increase in online shopping frequency before and during MCO for different modes of shopping has ultimately contributed to the growing appetite for single-use plastics. During MCO, online shopping of 3 to 4 times a week have increased by 7%; food delivery of 1 to 2 times a week have increased by 6%. The use of plastic bags, containers, cutleries, and straws of more than 4 pieces per week have increased by 33%, 49%, 31% and 31%, respectively (Thung and Saad, 2020).
Republic of Korea	• According to the Ministry of Environment, on average 850 tons of plastic waste was generated a day in the first half of 2020, which is a 16% increase compared to same period a year earlier (Sarah, 2020). • As the food delivery and increased so did the disposable plastic boxes. As a result, the amount of plastic waste collected per day reached 8.53 million metric tons in 2020, a 14.6% percent from the daily average of 7.44 million tons a year earlier (Jun tae, 2021).
Taipei, Taiwan	According to Taipei's Department of Environmental Protection, the number of discarded take-out containers in the capital Taipei between January and May 2021 increased by 85% compared to the same period last year (CNA, 23 Jul 2021).
United Kingdom	During lockdown, British household generated 128 pieces per week (as against 99 pieces per week in pre-COVID). 68% was food and drink packaging – including fruit and vegetable packaging, snack wrappers, parcel bags and PPE – and the increase of deliveries in lockdown may have contributed to the increase of plastic waste particularly (Everyday Plastic, 2020)

Because of their short lifespan, low recycling potential due to contamination with food residues, and is easier and cheaper to make new items than reclaim, disposable plastics from the food servicing sector are highly likely to continue ending up in our waterways and ocean. With the possibility of online shopping for food and grocery to continue in the post-pandemic era, and hygiene concerns much likely to stay put, plastic pollution from the food sector will continue becoming a pressing environmental concern.

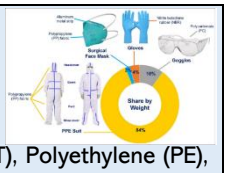
2.2 COVID-19 and disposable plastics in the medical sector

Plastics is a preferred material of choice even for many medical applications. Ability to be sterilized easily make plastics suitable for surgical and procedural applications including diagnosis and treatment tools and equipment, medical devices, tissue engineering, and sterilized packaging of pharmaceuticals. With the COVID-19 outbreak, disposable plastics continued to serve these regular medical applications, as well as for new usage such as body bags for wrapping the dead bodies of the COVID positive patients, millions of single-use diagnostic test kits, medical devices including oxygen concentrators, respirators, and ventilators, and drug delivery devices to administer COVID-19 vaccine. The biggest use, however, is the personal protective equipment (PPE) set (surgical mask, gloves, face shield, gown, shoe cover, head cover etc).

Although these plastic based PPE are not new to health care institutions, the uniqueness that COVID-19 brought was the heightened use of these PPE in non-clinical setting too. With governments in few countries releasing Public Health guideline for mandatory use of face mask in the public places as source control to reduce community transmission to self-reported mask wearing habit has made its use widespread in non-clinical setting as usual, which is atypical in other health crisis in the past. In addition to the single-use plastic-based PPE (mask in particular), hand sanitizer and disinfectant wipes packaged in single-use plastic wraps and bottles are another addition of disposable plastics that became essential to keep oneself protected from coronavirus exposure and transmission.

Text Box 2-3 Typical composition of PPE kit

A typical PPE kit composition includes 84% by weight of PPE suit, followed by 10% of eye googles, 4% of gloves and 2% by weight is surgical mask (Kumar et al. 2020). PPE is made from multiple plastic fibers, primarily polypropylene. The commonly used three-layer face mask (non-surgical) is made up of polypropylene (PP) polyurethane, polyacrylonitrile, polystyrene, polycarbonate, polyethylene, or polyester. Recent studies using FTIR-ATR confirmed the polymers such as Acrylonitrile butadiene styrene (ABS), Nitrile-butadiene rubber (NBR), Polybutylene terephthalate (PBT), Polyethylene (PE), Polyester (PET), Polypropylene (PP) and Styrene-Butadiene rubber (SBR) in the PPE (Robin et al. 2021).



The resulting global warming potential for the manufacturing of single-use medical face masks is calculated to be about 21.9 tonnes CO_2eq per tonne face masks (Graulich et al. 2021).

During COVID-19 outbreak, the demand and usage of plastic based PPE items was estimated to run in millions on the count. In a conservative estimate, if every person in the globe uses one disposable face mask per day, the pandemic could result in a monthly global consumption and waste of 129 billion face masks (3 million face masks used per minute) and 65 billion gloves (Prata et al. 2020). The WHO in 2020 estimated 89 million medical masks, 76 million examination gloves, 1.6 million goggles per month for the COVID-19 response. Hence, WHO has requested to increase manufacturing of PPE by 40% to meet this rising global demand production (WHO, 3 Mar 2020). According to the analysis by GREAT for GROWTH, 2021, in 2019 the medical PPE market was ~US$ 8 billion. China and the US accounted for ~60% of global production across most types of PPE, with the exception of gloves, which were mostly made in Malaysia and Thailand. Because of COVID-19 pandemic, global production of medical PPE increased by at least 300%, principally driven by demand for masks – medical mask manufacturing spiked by as much as 1,200% - with global demand for mask in 2019 at ~5% to expected to reach ~40% in 2021. The dramatic rise in demand for masks, goggles, gloves, and gowns has been recorded in many countries and PPE made most of the increased medical waste as compiled in **Table 2-3** below.

Table 2-3 COVID-19 and PPE consumption

City/Country	PPE used
China	During the state-wide lockdown, China used 900 million facemasks daily (Regazzi et al. 2020)
India	• Around 2,500,000 PPE estimated to be required per day to fight COVID-19 (Bose, 2020) • From no PPE kit production at all before the COVID-19 pandemic (until Jan 2020, only manufacturing a few products, like medical gowns and surgical gloves), India now produces nearly 4.5 lakh PPE kits every single day. In 60 days, the PPE industry in India has witnessed 56 times growth. (Lakshmanan and Nayyar, 25 May 2020)
Thailand	Around 1.5-2 million masks are nationwide used per day (Simachaya, 2020)
Bangladesh	Around 455 million surgical masks and 1,216 million disposal hand gloves, 189 million surgical gloves have been used during the first month of COVID-19 pandemic lockdown (26 Mar -25 Apr 2020) (Islam, 2020)
Hong Kong	The Environment Bureau estimates that up to 15 tonnes of non-recyclable discarded masks are being sent to the city's landfills every day, equivalent to the weight of a double-decker bus (South China Morning Post, 7 Aug 2020)
Victoria, Australia	An estimated daily generations of used face masks during the first wave and second wave of the pandemic in Victoria were approximately 104 and 160 tons (Boroujeni, Saberian and Li 2021).

COVID-19 contributed to a major shift in the usage of plastics tailored for medical applications, mostly the PPE, hinting a switch in sentiment over disposable plastics as a life saver. However, improperly discarded single-use PPE (mask, gloves) littered on streets, floating on waterways, and sunk in deep oceans has become a symbol of pandemic plastic pollution, both macro and microplastics pollution. An estimate shows that approximately 3.4 billion single-use facemasks/face shields are discarded daily as a result of COVID-19 pandemic, globally (Benson, Bassey, and Palanisami, 2021). A single surgical face mask that weighs roughly 3.5 gram, can release as many as 173,000 microfibers per day (Saliu et al. 2021 **Table 2-4** below compiles the PPE waste (masks) generated across the world.

Table 2-4 Increase in disposable PPE during COVID-19

City/Country	PPE waste generated during COVID-19
China	200 kg (over 200 public dustbins in Wuhan alone) (Jiangtao and Zheng 2020)
India	According to the Central Pollution Control Board (CPCB)[6], India produced 45,308 tonnes of COVID-19 biomedical waste (including PPE kits, masks, shoe covers, gloves, human tissues, items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs, beddings contaminated with blood or body fluid, blood bags, needles, syringes etc) between June 2020 and May 10, 2021, an average daily generation of 132 tonnes of COVID-19 related waste, a 17% increase in biomedical waste generation solely because of the pandemic (Kumar, 5 June 2021).
Thailand	According to the Department of Pollution Control, - Nationwide, an approximate of 1.8 billion face masks are being discarded daily - 17.8 tonnes of face masks were collected from 2,690 locations from all over Thailand between June 1 to Dec 31, 2020. (Bangkok Post, 29 Apr 2021)

[6] https://cpcb.nic.in/covid-waste-management/

Malaysia	According to survey and estimate by Dr Theng Lee Chong, an environment and waste management specialist as reported in a report by The Star Online, Malaysians use and dispose more than ten million face masks a day. This is based on 70% of 22 million Malaysians willing to use face masks in public places (Zainal, Trisha and Kaur, 10 August 2020)
Bangladesh	Around 14,165 tonnes of plastic waste have emerged from the use of single-use surgical face masks, hand gloves and polythene bags in communities, hospitals, and other health care facilities • 455 million surgical masks (1592 tonnes) • 1216 million polythene hand gloves (3039 tonnes) • 189 surgical hand gloves (2838 tonnes) • 1449 million polyethylene grocery bags (5796 tonnes) • 49 million hand sanitizer bottles (900 tonnes) (ESDO, 2020)
Hong Kong	The Environment Bureau estimates that up to 15 tonnes of non-recyclable discarded masks are being sent to the city's landfills every day, equivalent to the weight of a double-decker bus (South China Morning Post, 7 Aug 2020)
Taiwan	From February to May 2021, Taiwan produced 1.3 billion face masks. Each mask weighs approximately 4 grams, which adds up to 5,500 tons over three months. This amounts to so much waste that 1,100 garbage trucks would be required to collect and dispose of it, according to estimates by environmental group Greenpeace (Wu, 2021)
Victoria, Australia	An estimated daily generations of used face masks during the first wave and second wave of the pandemic in Victoria were approximately 104 and 160 tons (Boroujeni, Saberian and Li 2021).

Usually, disposable PPE are not recyclable, and the reuse is not a preferred measure recommended except a dire shortage in the supply situation. These discarded PPE is a threat to oceans and marine life, biodiversity, and human health (Robin et al. 2021). Such improper handling and disposal of used masks and gloves might spread of the infection further. Also, inappropriately disposed PPE may lead to microplastic discharge, colonization of invasive species, and entanglement or ingestion by apex predators" (De-la-Torre et al. 2021).

2.3 COVID-19 and disposable plastics in the tourism sector

Tourism industry is both generator and a victim of plastic waste. Tourism is plastic-intensive industry, where all tourism business value chain including travel and transportation, accommodation, food and beverage, and recreation and entertainment consumes single-use plastic products. At the same time, pollution decreases tourism-related incomes as litter on tourist destinations such as beaches full of plastics keeps tourists away, as well as there is a huge economic cost related to the cleaning and maintenance of the sites, and there are environmental externalities too. It is estimated that marine pollution has cost the Asian Pacific Economic Cooperation (APEC) region a US$ 622 million (Mcllgorm 2009). Similarly, the Island of Goeje in South Korea lost US$ 27.7 and US$ 35.1 million in revenue from tourists due to marine pollution on the beaches (Jang et al. 2014).

Travel, especially the aviation sector is yet another sector known for its intense consumption of disposable plastics. Main source of plastics waste from air travel is the in-flight catering with meals packaging (individually wrapped/packaged snacks, meals and beverages, cutlery, cups), and plastic wrapped blankets, pillows and headsets, cleaning wipes, etc. According to the International Air Transport Association (IATA), which conducted a composition analysis on cleaning and catering waste from 17 international flights arriving at London Heathrow Airport between September 2013 and January 2014, average passenger generates 1.4 kg of waste per flight (average across both short and long-haul international flights), of which 23% was untouched food and drink and 17% of recyclable materials including plastic bottles and newspapers (IATA, 2014). IATA estimates that in 2018 approximately 6.1 million tonnes of waste were generated (Moynihan and Walków, 2019). Not only the in-flight waste, but SUPP in airports (food containers, food packaging, beverage bottles, plastic shopping bags etc. provided by vendors in airport terminal) is also another source of plastic pollution associated with business and leisure travelling.

Hospitality industry, hotels, and accommodation service providers are another integral business of tourism sector. SUP consumption in hotels resonates to multiple single-use toiletries packaged in plastics such as shampoo, shower gel, soap, lotion, shower caps, Q-tips, dental kits, sewing kits etc. SUPP in hotels are found beyond these bathroom amenities in the form of dustbin liners, slipper wrappers, welcome/complimentary food/fruits wrapped in cling films, water bottle, coffee sachets, and food packing from breakfast buffet etc. Since most accommodation facilities also provide in-house dine-

in services, food packaging waste accounts as another critical source of disposable plastics. There are estimates that a single four-star hotel with 200 rooms in its full capacity can use around 300,000 pieces of single-use plastic products in a month. Of these items, plastic water bottles top the chart with 20,000 pieces, 49,765 plastic amenities and amenity packages, 216,693 pieces of plastics for food and beverage operations, including plastic wrap, storage bags and latex gloves, and 13,375 plastic bags. This staggering number is excluding plastics used by third-party plastic laundry bags used by third-party services to protect laundered clothing for staff and guests, and bags used by food suppliers (Zengkun, 2019). According to the response by 69 hotels' own operations, 32% of SUP products by weight was linked to water bottles, 31% to toiletries, 15% to bags and liners, 9% to food packaging, 3% to cups, 4% to cling film, 3% to other miscellaneous packaging, 1% to cutlery, stirrers and straws and 1% to small food products (UNEP & WTTC, 2021). Another estimate shows that the SUPP footprint of the international hotel industry is 150 million tons a year (Humble, 2021).

Coastal tourism is one of the most popular form of tourism, and one the fastest growing areas within the world's tourism industry, with eight out of ten tourists travelling to coastal area with beaches[7]. Coastal tourism contributes to beach littering and marine plastic pollution through consumption of disposable plastics straw, bottles, cigarette butts, flipflops and many more SUPP. During peak tourist season in summer, over 200 million tourists visiting the Mediterranean each year generate a 40% increase in marine litter during summer (Galgani et al. 2014).

Besides leisure coastal tourism, **religious/faith tourism** the most niche form of tourism, and probably one of the oldest forms of tourism, is also a contributor of plastics leakage to waterways. People from all sects of religion travel for performing worship, expressing gratitude, confess in, perform a vow, or commemorate and celebrate religious and cultural events, for spiritual salvation, and these religious sites, monuments or destinations have a link to waterways. Like leisure tourism activities, religious tourism also consumes single-use plastic products and packaging through travel, food & lodging. In addition, a special act making a religious offering (including deity's idols, food, fruits, flowers, lanterns, and decoration etc.), and into waterways (lakes, wetlands, rivers, oceans) causes a concern of plastics leakage into waterways and waterbodies in places with inadequate and inefficient waste management systems. Traditionally, these offering used to be biodegradable but with time plastics have made their way into such religious idols, offering packaged in plastics etc.

With the travel ban and mobility restriction and social distancing being the measures taken by almost all countries across the globe to contain the spread of the coronavirus, travel & tourism sector (leisure and religious) was also deeply impacted. According to the United Nations World Tourism Organization (UNWTO), the COVID-19 pandemic caused 1 billion fewer international tourist arrivals, causing a loss of US$ 1.3 trillion in total export revenues from international tourism, and putting 100 to 120 million direct tourism jobs at risk (UNWTO, 2021). Travel restriction is loosening a bit with COVID-19 vaccination roll-out, and partial domestic and international travel and tourism restarting. However, this sector still suffers a drop of international tourist arrivals (overnight visitors) by 83% in the period January-March 2021 compared to 2020, and by regions, Asia and the Pacific continued to suffer the largest declines with a 94% drop in international arrivals in the first quarter of 2021, compared to 2020, according to the UNWTO World Tourism Barometer (update May 2021)[8].

With international travel and tourism reopening slowly, like any other sector resuming its operation in the 'new-normal' context, it is crucial for the travel and tourism to also respond with a strong focus on health and hygiene. This renewed focus on health and hygiene could mean increased use of SUPP and more plastics waste generated by travel and accommodation sectors.

More to regular in-flight disposable plastic waste, the heightened focus on air travel hygiene in a closed space like an aircraft. One immediate and most distinct changes have been the requirement of PPE during flights. In the International Civil Aviation Organization's (ICAO) Take-off guidance for safe operations during the pandemic, developed jointly with the World Health Organization (WHO), governments and industry, wearing a mask when traveling by air is mandatory (ICAO, 2021). Some airports are now seeing more mask and PPE waste than ever before, adding the single-use plastic

[7] https://www.unep.org/news-and-stories/story/tourism-tackle-plastic-pollution-new-commitment
[8] https://www.unwto.org/unwto-world-tourism-barometer-data

footprint and the burden of safely handling these new kinds of potentially infectious PPE waste. The other likely change in air travel during the pandemic is the adjustments in in-flight food servicing, switching back to more disposable plastics in inflight meals.

Text Box 2-4 Examples of COVID-19 and disposable plastics from air travel industry

International Civil Aviation Organization, Take-off: Guidance for Air Travel through the COVID-19 Public Health Crisis

Non-medical and medical masks should be worn in line with WHO recommendations and the applicable public health guidelines, including requirements of all States concerned (e.g., departure, transit, arrival). Airlines should advise passengers in advance on type of masks required by the relevant national public health authorities. Except for the exempted groups (e.g., children up to 5 years or passengers that cannot tolerate non-medical or medical masks such as individuals with physical disabilities, respiratory or other conditions), who should be clearly specified.

- It also recommends the employee/ground staff at the airports to be equipped with PPE. For crew, the guidance suggests exploring an additional means of protection, in the form of plastic curtains or Plexiglas panels during the boarding process (to be removed once boarding is completed).
- Limit or suspend food and beverage service. Food and beverage service should be limited or suspended on short-haul flights or should be considered to be dispensed in sealed, pre-packaged containers.
- The use of non-essential in-flight supplies, such as blankets and pillows, should be reduced to minimize the risk of cross infection

The Guidance further considers handling cabin waste, including medical and non-medical mask, if no passenger or crew member exhibits COVID-19 symptoms as normal waste, as recommended by WHO, and disposed of in line with the procedures for such waste applicable in the State of destination. However, if non-medical and medical masks that have been used by a person suspected by the cabin crew of having COVID-19 or visibly soaked with blood or body fluids should be treated as biohazardous waste. If a passenger or crew member exhibits COVID-19 symptoms, all waste materials including partly consumed meals, beverages, and disposable items as well as used paper towels, tissues, and PPE (including non-medical and medical masks), generated whilst treating or supporting the passenger or crew member should be treated as biohazardous waste. By placing it in the biohazard waste disposal bag in the aircraft. The used PPE/mask, tissue waste is to be sealed and collected as biohazard waste (ICAO, 2021).

Non-medical) PPE litter at airports in India

Used PPE (mask, gloves, face shield, Hazmat suit) in airport terminals are being discarded improperly by arriving passengers in the airport terminals (Picture from Kolkata airport). Despite the large green bins marked for PPE waste placed at the baggage claim lounge and the arrival level where passengers exit the aerobridge, and staffs deployed to clear the PPE waste regularly so that it does not overflow, PPE littering has been observed in many airports triggering safety issue.

PPE litter at Kolkata airport
https://timesofindia.indiatimes.com/city/kolkata/carelessly-discarded-ppe-at-airport-trigger-safety-alarm/articleshow/76376093.cms

Adjustment in the in-flight meal servicing during COVID-19 and potential changes in the consumption of disposable plastics

Pre-packaged personal snack bag

Concerning safety and hygiene, airlines are making innovative changes in their in-flight meal servicing. In the beginning, many airlines discontinued in-flight meals, then resumed food and beverage service on board with few adjustments. The obvious change is serving the pre-packaged personal snack bags aiming at decreasing touch points on board.

Delta airline that initially discontinued the in-flight meal, later upon feedback from travellers, started serving snack bag consisting of Cheez-It crackers, Biscoff cookies, 8.5 oz Dasani bottled water, *Hand sanitizing wipe*, Cocktail napkin, that *comes in a plastic packet* to its domestic flight passengers.

https://news.delta.com/bag-new-snack-bags-now-onboard-domestic-delta-travelers

Food & Beverage pre-order

Transavia airline launched a unique partnership with online food delivery platform ***JustEast,*** allowing in-flight food pre-ordering to be delivered to their flight. The pilot programme developed in cooperation with Amsterdam Airport Schiphol and iFleat is currently available on four flights from Amsterdam to destinations in Greece, Portugal and Italy. It is expected to extend to more flights and airports. Passengers can order a meal through Just Eat's platform up to one hour before their flight and payment made upfront. The delivered meals are then served by the cabin crew, which reduces contact between passengers and crew. The innovative service is also expected to minimise food waste by reducing the number of meals that are prepared and brought on board but not consumed. However, it might add more disposable plastic waste. Several airports in the US have also launched food & beverage pre-order initiatives, including Philadelphia, Chicago Midway, Dallas/Fort Worth Airport, and Los Angeles International.

https://www.futuretravelexperience.com/2020/11/5-inflight-trends-resulting-from-covid-19-that-can-optimise-the-onboard-experience-reduce-costs-and-empower-crew/

The COVID-19 Pandemic has also affected the single-use plastic products consumption in the **hotel industry**. Efforts to reduce SUPP in hotels by banning unnecessary plastic items, banning plastic straw, replacing plastic amenities with biodegradable materials, and transitioning to reusable items seem to be affected as these SUPP are being considered safer and the preferred go-to option.

With COVID-19, the hotel industry has also expanded its service as a quarantine facility for travellers. These **quarantine or isolation hotels** are offering rooms to health care professionals in the area, as well as travellers requiring mandatory quarantine. Catering this new clientele adds responsibility to manage a huge volume of plastic waste that is potentially infectious. In quarantine hotels, meals are provided in disposable plastic containers with plastic cutlery, water in plastic bottles, and tea/coffee in disposable cups. On top of these regular SUPP is the PPE (mask, gloves, gown, face shields, shoe cover) used by the hotel employees and the guests.

Text Box 2-5 Disposable plastics from safety and hygiene operations at hotels operating as quarantine facilities during COVID-19

A staff member at the hotel (in Thailand) spraying luggage before it was taken to their rooms
https://www.abc.net.au/news/2021-02-19/what-i-learned-about-thailands-hotel-quarantine-system/13163526

The hallway covered in plastic sheet of a hotel room at the federally designated quarantine site near the Calgary airport, Canada, and food and supplies are left in containers outside guests' rooms
https://www.ctvnews.ca/health/coronavirus/canada-s-covid-19-isolation-hotels-complaints-of-secrecy-poor-communication-1.5304344

Light switches are wrapped with plastic wrap during Covid quarantine - Picture of CHECK inn Taipei, Zhongshan District https://www.tripadvisor.com/LocationPhotoDirectLink-g13808671-d5602542-i479260791-CHECK_inn_Taipei-Zhongshan_District_Taipei.html

COVID-19 Guidance: Setups and Management for Quarantine Hotels in Taiwan, requires:
Television remote controls, air-conditioning buttons or other touch panels should be covered with films. Films should be changed once the guests who are under home quarantine or isolation check out. The rooms should provide disposable toiletries and table-wares. Unused disposable goods from the previous guests not to be left for the next guest-unopened items should be retrieved and placed centrally and kept for at least 7 days before they can be used.https://fightcovid.edu.tw/cdc-guidelines/quarantine-hotels

Single-use plastic meal packaging at a quarantine hotel

Hotel guest with 288 pieces of plastics during his 21-day quarantine in Hong Kong

https://www.scmp.com/news/hong-kong/health-environment/article/3149307/plastic-trash-piling-hong-kong-green-groups-want?module=inline&pgtype=article

Religious tourism during COVID-19 has equally been affected due to the travel ban, physical distancing requirement and restriction on social gathering. With reduced religious travel and tourism and conglomeration, it is expected that the SUPP waste from religious tourism activities during the pandemic would have also reduced.

Text Box 2-6 Disposable plastics waste during Kumbha Mela in India

Despite the COVID-19, 9.1 million pilgrims took the holy dip in the Ganga from January 14 to April 27 in the Haridwar Kumbh Mela 2021(Rawat, 2021). This congregation is of immense religious and cultural significance for Hindus. People take holy bath in these scared rivers. These massive congregations contribute to plastic pollution to rivers. The government of India (through Clean Ganga and Clen India Mission among others), NGOs, individuals are working towards reducing garbage and sewage pollution from Ganges.

To mark Maha Kumbh 2021 clean and polythene free, 'Paryavaran Committee (Paryavaran Samiti) 2021' has been formed with an aim to make the Kumbh polythene free by using the concept of Eco bricks formation. This will require pilgrims to collect single-use polythene bags, plastic bottles, make Eco bricks. One Eco brick can carry 350-gram plastic that can otherwise litter 100 Sq Ft area. Polyethylene bags are the most common plastic garbage during Kumbh celebration.
https://paryavaransanrakshan.org/wp-content/uploads/2021/02/Polythene-Mukt-Kumbh.pdf

The COVID-19 pandemic has made the already SUPP intensive food servicing, medical, and tourism sectors consume more SUPP in the pretext of the increased focus on safety and hygiene in the '**new-normal**' context.

3. Plastics waste management during COVID-19

Heightened use of regular and new forms of single-use plastics, disruptions to waste management operations, the low oil prices discouraging global plastic recycling market during the pandemic has changed the landscape of the plastics. There has been policy reversals or temporary suspension of SUP ban and promotion of reusables reported. Rise in incidents of increased illegal disposal of COVID-waste during the pandemic are also reported during the pandemic. On a positive note, many global and national guidelines and guidance were made available to collect, decontaminate, transport, treat and dispose the COVID-19 induced waste management.

3.1 Guidelines & practices on COVID-19 waste handling & management

Municipalities and private waste management service providers continued their waste management practices during COVID-19 pandemic according to their existing infrastructure and resources availability, with some adjustments to adapt to the risks of virus transmission while handling waste (**Figure 3-1**). Some of these adjustments in MSW management related to the coronavirus crisis are; strict segregation of waste, specially masks, tissues and gloves from households with COVID-19 patient under mandatory quarantine, chemical disinfection and sealing, ensuring health and safety of waste management collectors and operators by strictly adhering to enhanced hygiene standards, including proper use of PPE, and ensure continuity and sufficient frequency of collection of waste in order to prevent littering, leakage and immediate risks to public safety and health.

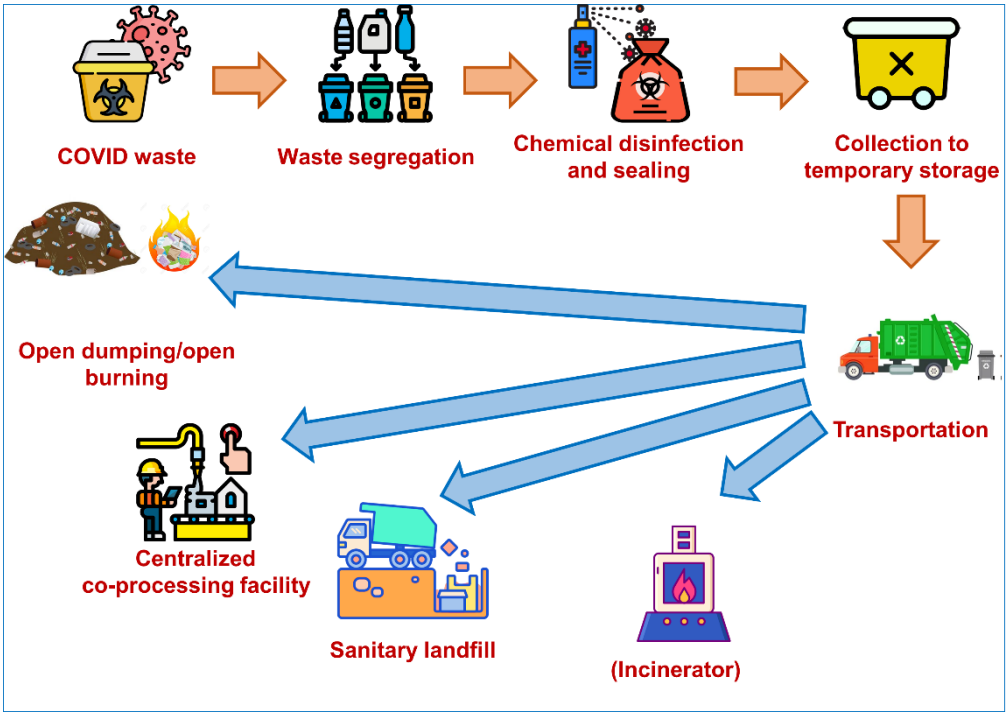


Figure 3-1 MSW management practice during COVID-19

These are guided by many global, and/or national COVID-waste handling & management guidelines, as compiled in **Table 3-1**. The commonalities in these Guidelines are the suggestion to segregate the used masks, gloves, and wipes/tissue paper and double bag it, and segregate households' recyclables separately. Regarding the safety of waste collection crew and waste operators, wearing gloves before handling any waste, and washing hands, and decontaminate PPE is recommended. For recycling facilities to operate using hygiene and safety measures including maintaining social distancing, disinfection or stored separately for 72 hours if recyclables are known to have been in contact with COVID-19 is recommended.

Despite such Guidelines, city authorities faced additional burden in managing the increased volume of potentially infectious municipal plastic waste. Low segregation of PPE from non-clinical setting and an increased littering, leakage of potentially infectious waste posing an immediate risk to public safety and health were the prominent challenges in managing the pandemic waste.

Table 3-1 Guidelines for safe handling & management of COVID-19 induced waste

Organization	Guidelines/recommendations
WHO (2020)	The WHO's Interim Guidance - Water, sanitation, hygiene, and waste management for SARS-CoV-2, the virus that causes COVID-19 (released on 29 July 2020) suggests waste handling at home during quarantine, while caring for a sick family member • Single-use masks and gloves must be discarded after each use. • Health-care waste including used PPEs (gloves, masks, goggles, fluid-resistant apron) must be collected in clearly marked lined containers and sharp safe boxes, and stored, preferably on-site prior to treatment and safe disposal. • Waste produced at home during quarantine needs to be packed in strong black bags and sealed properly prior to collection by the municipal entities. • Health-care waste should preferably be treated by autoclaving or high temperature burn incinerators.
GEF, UNDP, WHO and HCWH (Green health care waste, 2020)	• Has released a FAQ and Decision tree for the treatment of COVID-19 waste. • The Decision tree suggests strict segregation as a critical step in safe health care waste management. Infectious waste is recommended to treat using the best available technology (BAT) such as an autoclave or high temperature double chamber incinerator fitted with air pollution control equipment, preferably using on-site treatment facility. If no on-site facility is available, infectious waste is to be safely transported to a central BAT treatment facility. In an emergency, and in absence of such facilities, controlled burning or deep burial are to be considered as short-term/interim measures
ADB 2020	• Infected COVID-19 solid waste (including PPEs) must be double bagged before treatment/disposal. • COVID-19 infected domestic/medical waste (plastics included) should not be recycled and must undergo incineration or sanitary landfilling.
UN-Habitat, 2020	UN HABITAT has published a Strategic Guidance – Solid waste management response to COVID-19. This Guideline keeping the critical elements of pandemic waste management suggest 10-point strategy for solid waste management operations in the context of COVID-19: 1. Map sources of waste generation to identify changes in waste amounts/flows and increase efficient use of resources 2. Separate infectious waste in households – red colour bag/double bagged and sealed 3. Maintain and expand waste collection services 4. Ensure safe waste treatment and disposal 5. Protect waste workers, formal and informal 6. Regularly communicate with citizens and stakeholders 7. Engage with stakeholders 8. Accelerate procurement procedures 9. Apply national and international guidance 10. Design scenarios and contingency plans
UNEP, 2020	UNEP has also released a series of COVID-19 Waste Management Factsheets outlining advice to mitigate the adverse impacts of the pandemic on global environment. Factsheet #7 specifically advices on Household medical waste management strategies. It suggests during the COVID-19 pandemic, additional waste needs to be segregated at the household level in dedicated containers. • If there is a suspected or confirmed COVID-19 case in a household or people are in quarantine, then waste must be considered potentially contaminated and handled with care. The waste container should be sealed, temporarily stored, and collected at the first opportunity to prevent the risk of spread of the disease • To reduce direct contact with medical waste, any bag liner should be sealed before the bag is 70% filled. Waste handlers should ensure they wash hands thoroughly after sealing any bags. For extra safety, the bag can be put in another bin liner of a specific, recognizable colour (often yellow)

Organization	Guidelines/recommendations
	• Stored waste should be kept safe from possible scavengers. Temporary storage at the household level avoids further overloading of the medical and regular waste management systems. • Service providers should put in place specialized teams of trained workers that are provided with personal protective equipment. The waste company should use designated vehicles for handling household medical waste and be familiar with the safe use of disinfecting equipment. They should also play a role in helping to inform the public on how to handle household medical waste and promote segregation at the household level • Open dumping and open burning of medical household waste should be avoided • Factsheet #5 guides for implementing measures to increase the circularity of household products through strict segregation from infectious waste and innovation in designing new products and business models to improve the 4R (Reduction, Reusability, Repairability, and Recyclability & Recovery). • It also suggests that MSW management systems need to be properly organized and equipped to deal with household medical waste, including information and advice on clear labelling as well as source segregation of waste, transportation, disinfection, storage and treatment, as a way forward to manage MSW in pandemics.
Bangkok Metropolitan Administration (BMA), Thailand	• BMA has issued guidelines for disposal of face masks as well as antigen Covid-19 test kits for home use • Used facemasks to be strictly separated from other household waste; put it in ziploc bags or bags that are tightly sealed and labelled as 'mask' or 'infectious waste' before handing them to garbage-collection trucks or at specified drop-off location. BMA has placed special bins (red bins) for used face masks in 173 locations across Bangkok. Used masks thus collected are then incinerated at garbage disposal facilities in Nong Kham and Onnut. BMA guideline for disposal of antigen Covid-19 test kits approved for home use is similar to disposal of face masks 
Ministry of Ecology and Environment, China (MEE 2020)	• Collection and disposal of infectious plastic medical waste generated during the pandemic must be the priority for medical waste disposal units. • Treatment facilities like incineration for domestic and hazardous plastic waste generated must take place in accordance with the competent medical health authorities.
Central Pollution Control Board, India (CPCB, 2020)	• Double layered plastic bags must be used to collect the waste from COVID-19 isolation wards and Intensive Care Units. • Common Biomedical Waste Treatment Facility (CBWTF) operators should be timely informed about the generation of biomedical waste (including face masks, gloves) from quarantine centres for their timely collection and treatment. • Plastic BMW must be handed over to urban local bodies (ULBs) waste collector and should finally reach to CBWTF. • CBWTF operators must ensure health hygiene while handling COVID-19 infected waste (wearing layered masks, nitrile gloves, gumboots, safety googles and waterproof aprons/gloves). • COVID-19 plastic waste (googles, hazmat suits, nitrile gloves) should be disinfected/shredded/recycled. • Used masks, head caps, shoe covers must be incinerated.
Ministry of Health and Population, Nepal (MHP 2020)	• Auxiliary staff and health workers will undergo appropriate training to dispose the plastic-based PPEs. • Protective gears including facial masks, gloves, face shields, aprons/gowns must be used to avoid infection at different levels of the health care system.
Ministry of Health and Indigenous Medical Services, Sri Lanka	• Infectious waste generated from the impacted and non-impacted sources is advised to be segregated at the source itself using coloured-coded containers. • On transportation of the solid waste including infectious plastic waste to the treatment facilities, leakage or spillage must be checked to avoid contamination. • All the contaminated waste including plastic-based PPEs shall be incinerated or autoclaved following proper safety protocol.
Waste Management, Division - Industrial and Hazardous Waste Management Division, Ministry of the Environment, Gov of Japan (MoEJ, 2020)	Q & A to Implement Countermeasures to the Novel Coronavirus Infectious Disease (COVID-19) in Waste Treatment and Management (29 June 2020) Waste related to the novel coronavirus diseases which is discharged from households and offices should be treated according to the "Guidelines for Measures against New Influenza in Waste Treatment", in the same manner as the waste related to the influenza infection. Specific prevention measures include: • do not touch garbage directly; dispose of garbage before a garbage bag becomes full, and securely tie garbage bags; wash hands with soap immediately after the disposal; and effective to double bag the garbage to improve sealing https://www.env.go.jp/saigai/novel_coronavirus_2020/covid-19_waste_disposal_en.pdf

(Source: modified from Parashar and Hait, 2020)

3.2 Plastic management policy set-back

Pre-COVID, there were steady increase in policies to tackle the plastic pollution. Among them were regulatory approaches (e.g., bans and restrictions prohibiting the production, sale or use of SUPP), economic instruments (e.g., fiscal incentives or disincentives such as imposing taxes to deter production or use of SUPP), product standards, certification and labelling requirements, public policies aimed at improving waste, and voluntary responses and pledges to sustainable lifestyles. These policy interventions, however, have been mostly characterised by a narrow focus on specific SUPP and targeted towards downstream focus rather than policy interventions across the plastic lifecycle.

By July 2018, there were 127 countries enacting some form of legislation regulating plastics (UNEP, 2018). Plastic carrier bags are one of the plastics policy foci. According to UNEP & WRI (2018): 91 countries have implemented bans on plastic carrier bags. Further to this, while 27 countries have limited the production or consumption of other specific single-use plastic products (straws, cutlery) or materials (polystyrene). Plastic plates, cups, stirrers and cutlery are the most banned SUPP after plastic carrier bags (12 bans), followed by packaging and plastic bottles (6 bans each), and take-out food packaging (5 bans). Only 8 countries, including Canada, France, Italy, the Republic of Korea, New Zealand, Sweden, and the UK have established national laws to ban on microbeads in personal care products. European Commissions' Single Use Plastic Product Directive (SUPDD)[9] of 2019 that came into force by 3 July 2021, is the holistic policy that targets 10 SUP items that are most found on European beaches (Cotton bud sticks, Cutlery, plates, straws and stirrers, balloons and sticks for balloons, Food containers, Cups for beverages, Beverage containers, Cigarette butts, Plastic bags, Packets and wrappers, and Wet wipes and sanitary items). The directive delivers on the EU's plastic strategy, an important element in the EU's move towards a circular economy.

The changing landscape of SUPP with COVID-19 is not only limited to the volume of plastics waste generated or the composition of single-use plastic products and source/point of generation of SUPP waste but also changes in the policy attention or regulatory actions towards SUPP. Rather temporary, but a suspension of policies on banning of SUPP, reversal of initiatives that supported reusables, observed initially during COVID-19 pose a risk of delaying, and derailing of the efforts made so far on addressing the SUPP pollution. Such shift in SUPP policy is somewhat a result of misconceptions and unsubstantiated trust over single-use plastic products and packaging being a safer option to reduce virus transmission. This pandemic has therefore added the habitual use of SUPP as a matter of convenience with the contextual use too, where the fear over virus transmission has led to increase plastic packaging for food, and there is an obvious increase in the health care applications of plastics, majority of which is single use. During the COVID-19 pandemic, these behavioural biases that SUPP are better protector than reusables or products or packaging of alternative material have not only been reflected to consumers' behavioural biases but also into policy reactions preferring SUPP.

Text Box 3-1 Examples of policy and practices setbacks and acceleration addressing SUPP during COVID-19

United States[10][11]

- Maine postponed plastic bag ban
- New Hampshire and the city of Cambridge, Massachusetts banned reusable bags during the outbreak and ordered retail stores to use single-use paper or plastic bags
- The governor of California temporarily suspended the state's ban on plastic bags in April 2020 due to COVID-19, but brought it back 60 days later
- Citing COVID-19, the governor of the US state of Washington vetoed a bill that would have established minimum recycled content requirements for some plastic beverage containers
- Philadelphia's ban, approved in 2019, was to begin July 1, 2020, city officials was delayed - first pushed it to Jan. 1, 2021, and then to July 1 as during COVID-19 restaurants relying on takeout to stay afloat
- Multiple States paused their container deposit programs. The Department of Energy and Environmental Protection (DEEP) U.S. issued a press release on March 16, 2020, noting that it would be temporarily exercising "enforcement discretion" toward redemption of deposit containers at retailers that sell beverages subject to Connecticut's bottle bill program. This press release noted that this "temporary action will be in place through March 31, 2020, subject to possible extension in consultation with public health officials"

[9] https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:32019L0904
[10] https://www.foodpackagingforum.org/news/covid-19-challenging-epr-and-single-use-legislation
[11] https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2021/03/30/pandemic-paused-plastic-bag-bans-ripped-anew-by-critics

United Kingdom

- UK ***temporarily (***from 21 Mar – 21 Sep 2020) suspended the plastic bag charge ***for online deliveries (only)*** in England. This does not apply to single-use bags provided in store or for other types of online delivery[12]
- Citing COVID-19 as the reason, the UK government announced a delay in introducing a packaging deposit-return scheme - England, Wales and Northern Ireland shelved their deposit return schemes until 2024, Scotland is still working towards getting their 17,000 return points ready for the launch of the initiative in 2022[13]
- Ban on plastic straws, stirrers and cotton buds delayed by 6 months (originally due to come into force in Apr 2020 delayed being implemented only in Oct 2020). The reason given however was "because of the impact on businesses from the current coronavirus outbreak to avoid additional burdens for firms at this challenging time, and not due to lobbying from the plastics sector as incorrectly reported in media[14]

India

- The Plastic Waste Management Rules (PWM), 2016 (amended in 2018), banned the use of plastic carry bags below 50 microns' thickness all over the country. But, during COVID-19 plastic bags made its way back. For instance, Tamil Nadu Government in India on January 1, 2019, banned single-use plastic bags, but later in 2020 suspended bans of single-use plastic bottles and bags in retail trade[15].
- **Indian government's pledge to eliminate SUPP by 2022** - A central government committee has identified the SUP items to be banned in its 2021 New Draft Rules[16]. The new draft will replace the existing rules on plastic waste management which were notified in 2016 and amended in 2018. The 2021 draft rules have proposed to prohibit manufacture, import, stocking, distribution and sale of certain single-use plastics **from January 1, 2022.** In the three-stage ban, the first category of SUPP proposed to be phased out are plastic sticks used in balloons, flags, candy, ice-cream and ear buds, and thermocol that is used in decorations. The second category, proposed to be banned from July 1, 2022, includes items such as plates, cups, glasses and cutlery such as forks, spoons, knives, straws, trays; wrapping and packing films used in sweet boxes; invitation cards; cigarette packets; stirrers and plastic banners that are less than 100 microns in thickness. A third category of prohibition is for non-woven bags - widely used as shopping bags. below 240 microns in thickness. This is proposed to start from September 30, 2022.
- The plastic manufacturers, however, have expressed reservations. The All-India Plastic Manufacturers' Association (AIPMA), has requested the government to ***push the deadline*** for phasing out SUP products ***by a period of one year to 2023*** owing to economic distress faced by manufacturing units due to the Covid-19 pandemic.

South Korea

- Country's 2018 ban on plastic carrier bags and disposable single-use plastic prodcuts eased the restrictions on the usage of disposable plastic dishes, straws and cups use at cafes and restaurants[17].

Australia

- The South Australia Government had originally intended to stop sales of some single-use plastic products including straws and cutlery but was put on hold because of the coronavirus pandemic. The policy was delayed by a year (the ban will now come into place on March 1, 2021, instead of April 2020) to allow restaurants and cafes to continue using disposable items to improve hygiene amid the pandemic[18].

Thailand

- The onset of the COVID-19 pandemic has probably hindered the fight against plastic waste. Despite the Roadmap on Plastic Waste Management, 2018-2030, the COVID-19 has unfolded a situation where SUPP use, especially, from food deliveries has increased. This increase in food containers is concerning, because as per the roadmap, by 2022 Thailand plans to ban 4 types of single---use plastics, including thin plastic bags with thickness less than 36 microns, **styrofoam food boxes**, plastic straws, and plastic cups.
- On July 8th, 2020, the minister of natural resource and environment ordered PCD to set up a new action plan with food delivery companies aiming at reducing SUPP in the food delivery industry. Under the "New Normal Food Delivery with Environmental Care" Memorandum of Understanding, the Ministry of Natural Resources and Environment has joined with six food delivery services including Food Panda, Grab Food, Gojek and LalaMove. As per the MoU (signed on 01 October 2020), these online food delivery platforms are to add an opt-in button to their applications that will allow customers to decline single-use plastics as well as work with their restaurants to incorporate more environmentally friendly packaging or use a deposit-refund system for food container. https://thainews.prd.go.th/en/news/detail/TCATG201001133438073

Food retailers and restaurants refusing reusables

- Fast food retail chains including **Starbucks**[19] temporarily paused the use of reusable cups and food container in the store, as a way to help prevent the spread of the virus, however, still provided the 10-cent discount who bought their reusable cups with them
- Singapore's bubble tea brand Koi withdrew Bring your own container schemes
- Tesco, which previously banned using plastic bags or tray liners in its deliveries, had brought them back during the coronavirus pandemic. From April 19, 2021, though, plastic bags will not be available with online orders with Tesco. The reintroduction of bagless deliveries has been influenced by concerns over the environment and playing its role in reducing plastic consumption[20].

[12] https://www.gov.uk/government/publications/single-use-plastic-carrier-bags-why-were-introducing-the-charge/carrier-bags-why-theres-a-5p-charge
[13] https://www.bigblueoceancleanup.org/news/2021/5/4/why-is-britains-delay-with-its-deposit-return-scheme-bad-news-for-the-ocean
[14] https://deframedia.blog.gov.uk/2020/04/16/ban-on-plastic-straws-stirrers-and-cotton-buds-delayed-due-to-coronavirus-outbreak/
[15] https://www.thehindu.com/news/national/tamil-nadu/banned-plastics-available-all-over-city/article32768389.ece
[16] https://www.business-standard.com/article/current-affairs/what-india-must-do-to-implement-ban-on-single-use-plastics-effectively-121061700235_1.html
[17] https://mothership.sg/2020/02/covid-19-south-korea-ease-ban-plastics/
[18] https://www.abc.net.au/news/2020-12-23/sa-ban-of-single-use-plastics-and-straws-to-start-in-march/13009582
[19] https://stories.starbucks.com/press/2020/managing-courageously-through-the-dynamics-of-covid-19/
[20] https://www.walesonline.co.uk/whats-on/shopping/tesco-asda-morrisons-aldi-lidl-20348932

3.3 Disruption in waste management operations and plastics recycling during COVID-19

The impact of COVID-19 on plastics manifested in many ways. The pandemic drastically and rapidly changed plastic consumption patterns, increased volume of low value disposable plastics wastes especially from food servicing, e-commerce, and medical sector, disrupted waste collection, treatment, and management operations, and affected the global plastic recycling market. All these, affected the overall waste management capacities and efficiencies, potentially increasing the leakage of plastics into land and waterways.

Stretching human resources in performing regular work collection activities to budget implication in addressing health care and social protection costs to provide safety gears to it waste collection crews, disinfection of streets, waste bins and vehicles, municipal authorities and private waste management service providers were under both financial and physical challenges. Low segregation of potentially infectious PPE waste, and interruption in waste collection frequency and priority (priority was seen to be given in collecting residual waste more frequently than recyclables) increased the risk of street littering and leakage of plastics into waterways. Regular clean-up activities were also interrupted during the pandemic.

Disruption in waste management services also included temporary shutdown of municipal or privately owned (formal and informal sector) recycling facilities. Few municipal recycling facilities temporarily suspended their operation due to budget reallocation to cope with the pandemic. Rock Springs, Wyoming, and East Peoria, Illinois in the United States have cut recycling programs (Staub 2020). City authorities operated drop-off centres and kerbside recyclable collection points were temporarily closed. According to the RECOUP 2020 survey, over 50% of respondents (Local Authorities and Waste Management Providers) stated that COVID-19 had impacted their kerbside recycling collections in some way (Morgan and McBeth 2020). COVID-19 has forced even countries with greater recovery capabilities such as Italy (83%) to prioritize burning their waste, a common approach during epidemics such as Ebola in Africa and which is advised by WHO in the first stage of disaster or emergency responses (Julia 2020). In Delhi, residents stopped segregating the waste and the mixed waste with both high and low value recyclable material was sent to Bhawana Waste to Energy Plant (Arora 2020). The plant received waste more than its running capacity. Such changes in MSW treatment were because of the fear of the transmission of virus from the potentially infectious waste as well as to significantly reduce the increased volume of waste generated.

During COVID-19 lockdowns, Shanghai City suspended the separate waste collection for the centrally located neighbourhoods, allowing residents to split their waste in two fractions only – wet and dry – instead of the initial four - kitchen waste, recyclables, other waste and hazardous waste (Bloomberg 2020). Such disruption in recycling waste collection affected the existing good practices of the municipal plastics waste recycling. However, following gradual recovery from the pandemic, the obligation to split waste into four categories has been reinforced.

Figure 3-2 Influence of COVID-19 on municipal plastic waste landscape
(Source: modified from van Fan et al. 2021)

Private recyclers found it hard to survive, with business shrinking by as much as 60% in the U.S. and 50% in parts of Asia-Pacific (Ho 2020). According to the survey conducted by GA Circular and Circulate Capital (2020), more than 80% of the recycling value chain was not operating during the height of the pandemic in Vietnam, India and The Philippines, resulting in an increase of plastic entering landfills and, likely the environment. The recycling operators went through feedstock shortages, cash flow shortage,

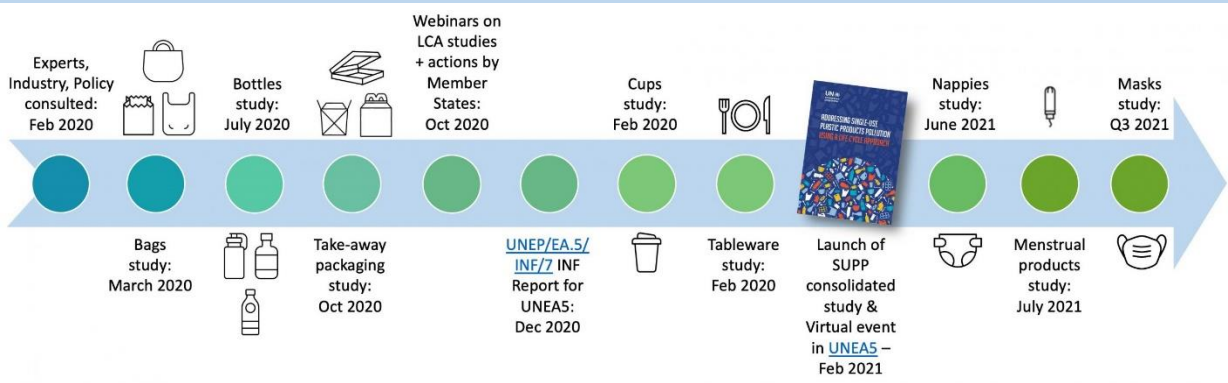
worker shortages, and other logistics barriers. The record low oil price marred the demand for recycled plastics as producing virgin plastic tuned out to be cheaper than recycled plastics. According to GA Circular, the global crude oil price needs to be higher than US$ 70 per barrel for recycled plastics to be competitive. Since the pandemic began in March 2020, recyclers across the five countries (Indonesia, Philippines, Vietnam, Thailand and India saw on an average a 50% drop in demand for their products and 21% drop in sales prices (GA Circular and Circulate Capital, 2020).

Single-use plastics pollution has come under additional pressure during the pandemic as there has been significant acceleration in demand for single-use plastics during the pandemic, disruption in waste management operations, and declining recycling during the COVID-19. This pandemic induced plastics pollution is more than a short-term eye-shore of littered streets and beaches that causes longer-term environmental effects. The pandemic has thus underscored the urgency to address existing inefficiencies in our plastics waste management system with a longer-term outlook and holistic solutions across the plastics value chain. It could mean taking a life cycle approach to addressing single-use plastics pollution through product design, business models and technology promoting plastics circularity, producing durable products; products with lighter product's weight (normally) that lowers its environmental impact, promoting reuse and expanding plastics recycling (UNEP, 2021).

Text Box 3-2 Life Cycle Assessment (LCA) meta-analyses to addressing single-use plastic products pollution

Life cycle assessment (LCA) is the calculation and evaluation of the environmentally relevant inputs and outputs and the potential environmental impacts of the life cycle of a product, material, or service. Such analysis help identify trade-offs and prevent burden shifting and allows decision-makers to better understand the impacts of consumption and production of products and services and complement evidence-based decision-making at reducing the environmental impact of single-use plastics products (SUPP). However, environmental footprints of SUPP alternatives will depend on a range of factors which need to be assessed on a case-by-case basis and LCA does not replace the need to draw upon a range of information sources when making decisions.

The Life Cycle Initiative, hosted by UNEP, is a public-private, multi-stakeholder partnership enabling the global use of credible life cycle knowledge by private and public decision makers, facilitates the application of life cycle knowledge in the global sustainable development agenda in order to achieve global goals faster and more efficiently. The Life Cycle Initiative has undertaken a number of LCA meta-studies assessing different product types and their alternatives



- **Addressing Single-use plastic products pollution, using a life cycle approach**: This report summarizes the key conclusions on the environmental performance of eight different single-use plastic products compared to their alternatives.
- Single-use beverage cups and their alternatives: Recommendations from Life Cycle Assessments
- Single-use plastic bottles and their alternatives: Recommendations from Life Cycle Assessments
- Single-use nappies and their alternatives: Recommendations from Life Cycle Assessments
- Single-use plastic tableware and its alternatives: Recommendations from Life Cycle Assessments
- Single-use plastic take-away food packaging and its alternatives
- Single-use plastic bags and their alternatives: Recommendations from Life Cycle Assessments
- Single-use menstrual products and their alternatives: Recommendations from Life Cycle Assessments

Source: UNEP (2021). Addressing Single-use Plastic Products Pollution Using a Life Cycle Approach. Nairobi: United Nations Environment Programme.

https://www.lifecycleinitiative.org/activities/key-programme-areas/technical-policy-advice/single-use-plastic-products-studies/

3.4 Illegal disposal, and illegal trade of plastics waste

With increased burden on waste management system, there has been reported incidences of illegal disposal of waste during COVID-19. Illegal dumping and open burning of waste which was already rampant in most part of Asia continued during the pandemic too. The surprising factor was that such illegal disposal was reported in Europe, and North America too. As City authorities put non-essential waste collection on halt and household waste recycling centres were closed, people took advantage to get rid of old furniture, clothes, electronics and often led to an increase of illegal disposal of waste as reported from the Netherlands, Belgium, United Kingdom and Portugal (Interreg Europe 2020). Ireland saw a sharp increase in dumping of household waste during the coronavirus pandemic, with illegal dumping rates up by 25% in Dublin city alone (Kelly 2020). The Minister for Communications, Climate Action and Environment, Ireland announced €1 million special funding from the Anti-Dumping Initiative budget to combat such illegal dumping. Across New South Wales, Australia too, there was a 34% increase in reports of illegal dumping incidents in April 2020 as compared to April 2019 (NSW EPA, 2020).

Legal plastics trade is a part of global plastic recycling, as plastic recycling occurs both locally and through export to developing countries in Asia. In Europe, 32.5% of post-consumer plastic waste collected was recycled in 2018. Out of which, 81% was recycled inside EU, and 19% Outside EU. Plastic waste exports outside the EU have decreased by 39% from 2016 to 2018 (PlasticsEurope, 2019). Approximately, 8 million metric tons (2%) equivalent to US$ 3 billion plastic waste was traded in 2018, according to the UNCTAD plastics trade database prototype as of October 2020 (UNCTAD, 2020). United States, Europe and Japan were the top exporters of plastic waste while Southeast Asia - Malaysia, Thailand, Viet Nam were the top importers.

Trade flows are dynamic and have changed in both quantity and the main import/export countries over time. Until Jan 2018, China accounted for two thirds of global trade in waste plastics (d'Ambrières, 2019), but, with China's National Sword Policy, 2018 which announced it would only accept bales of plastic waste with less than 0.5% contamination by non-recyclable materials (previously accepted up to 1.5% of contamination), the plastic scrap export did not qualify these and caused a large re-routing of illegal trade of plastic waste into South East Asian countries like Malaysia, Thailand and Vietnam. This is substantiated by the INTERPOL's 2020 report, according to which, there has been a considerable increase in illegal waste shipments camouflaged as recyclable plastics, from 2018-2020, primarily rerouted to South-East Asia via multiple transit countries (INTERPOL, 2020).

2020 has been a key year for substantial developments in the arena of illegal trade of plastics waste. In addition to the China's ban in 2018, on 25 Nov 2020, the Chinese Ministry of Ecology and Environment[21] issued an Announcement on matters related to the total ban on the import of solid waste confirming a total ban on import of solid wastes, including plastics, paper products and textiles, starting Jan 2021. This however is only for waste and not scrap material. The other key development is the Amendment of the Basel Convention[22] that came into force on 1 Jan 2021, according to which, any non-hazardous plastic waste that is not recyclable, or is 'difficult' to recycle, is now categorized as waste requiring 'special consideration.' The amendment requires getting a Prior Informed Consent (PIC) from the country of import prior to movement for mixed plastics, while 'Green list' waste such as plastics of which consist almost exclusively of one type of plastic that are destined for recycling operations, and mixtures of polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET) that are destined for separate recycling do not require PIC) and its movement is now subject to the Basel Convention prior notice and consent requirements.

These tighter regulations and legally binding frameworks legislations are expected to play a powerful role in stopping non-recyclable plastic that are being sent to developing countries and make the global trade in plastic waste more transparent and better regulated. As the recycling operates importing such waste do not have recycling infrastructure and capacity to recycle mixed plastic waste, there is a high likelihood of these imported plastics waste ending in illegal dumping and leakage to waterways and oceans. Such regulations are hence expected to help reducing marine plastic leakage.

[21] http://www.mee.gov.cn/xxgk2018/xxgk/xxgk01/202011/t20201125_809835.html
[22] http://www.basel.int/Implementation/Plasticwaste/Overview/tabid/8347/Default.aspx

A few countries, Malaysia in particular, has been very vocal against illegal import. The Malaysian government has been cracking illegal recycling operators and their facilities, training their custom officials to identify and control shipment with non-compliant material, and sending-off the containers full of plastics wastes to the exporting country. In 2020, the environment minister ordered 3,737 metric tons of trash to be returned to 13 countries - of the 150 containers, 43 were sent back to France, 42 to the UK, 17 to the US and 11 to Canada (Picheta, 20 Jan 2020).

Disruption in the waste collection, segregation and recycling activities during COVID-19 might have had an impact on illegal trade of plastics. There are not many substantial research or data to establish this claim, nonetheless, the increase in plastics use during the pandemic across the globe in some way mean discarding them, and illegal plastics trade is much likely to be one of the improper, but an easy option of doing so.

In fact, INTERPOL's 'Operation 30 Days at Sea 3.0'[23] conducted between (1-31 March 2021) by 300 agencies across 67 countries 34,000 conducted inspections at sea and inland waterways, coastal areas and ports resulting in an unprecedented to detect marine pollution violations revealed 1,600 marine pollution offences worldwide:

- Nearly 500 illegal acts of pollution committed at sea, including oil discharges, illegal shipbreaking, and sulphur emissions from vessels
- 1,000 pollution offences in coastal areas and in rivers, including illegal discharges of sewage, mercury, **plastics**, and other contaminants, leading to serious water contamination which flows into the oceans
- 130 cases of waste trafficking through ports.

13 cases of medical waste opened with disposable items such as masks and gloves were reported in the illegally shipped containers with plastics waste. This shows a trend that with COVID-19 a new kind of plastic items (PPE) is likely to be wrongly claimed and exported as recyclable, adding risks of infection and health hazards. In coming days, this trend is to be carefully monitored and controlled.

4. Outlook on surge in leakage of plastics in waterways and rivers during COVID-19

Each year, at least 8-12 million tonnes of plastics leak into the ocean. A recent study by the PEW Chariatable Trusts and SystemIQ, 2020 estimated an 11 million metric tons of plastic entered the ocean from land in 2016, and projects plastic flows into the ocean under the BAU scenario to nearly triple by 2040, to 29 million metric tons per year, which is equivalent to 50 kg of plastic per metre of coastline worldwide. An estimated 80% of global ocean plastics leakage is from land-based sources and 60% from urban centres (Lebreton and Andrady, 2019). Land based leakage occurs as exchange between land and waterways including city's canal, sewerage, and rivers. Uncollected waste generated in urban centres either directly gets dumped into waterways or enters the river system through surface run-off, and finally to ocean. In coastal settlements, these plastics leak as an exchange between land and ocean. Riverine plastic leakage in Asia and the Pacific was rampant even before the COVID-19 pandemic. Increased leakage of disposable food packaging plastics, plastics-based face masks into waterways and rivers stands a high likelihood during the pandemic.

4.1 Overall situation of plastic leakage in waterways and riverine plastic pollution in Asia & the Pacific

Riverine plastic leakage is comparatively under studied in comparison to marine plastic litter, nonetheless, in recent years there have been increasing studies and evidence of that rivers transport plastics into oceans. Together with active sampling, modelling, visual observations, and citizen science are being used to quantity riverine plastic leakage.

[23] https://www.interpol.int/en/News-and-Events/News/2021/Operation-30-Days-at-Sea-3.0-reveals-1-600-marine-pollution-offences-worldwide

As illustrated in **Figure 4-1** (Ritchie, 2021), Schmidt et al. 2017 estimated eight out of top ten rivers responsible for transporting 88–95% of the global plastic load into the sea are in Asia. These rivers are identified as Indus, Ganges, Amur, Hai He, Yellow, Mekong, Pearl, Yangtze (in Asia), and two in Africa- the Nile and the Niger contribute ~2 million metric tons of plastic annually. Similarly, another estimate from Lebreton et al, 2017 estimated that 10 rivers contribute to 56% of plastic inputs. New research by Meijer et al. (2021) finds that it's not only these 10 or 20 rivers but 80% of plastic waste is distributed by 1,656 rivers emitting between 0.8 million and 2.7 million metric tons of plastics per year. It also estimates that small urban rivers are the most polluting.

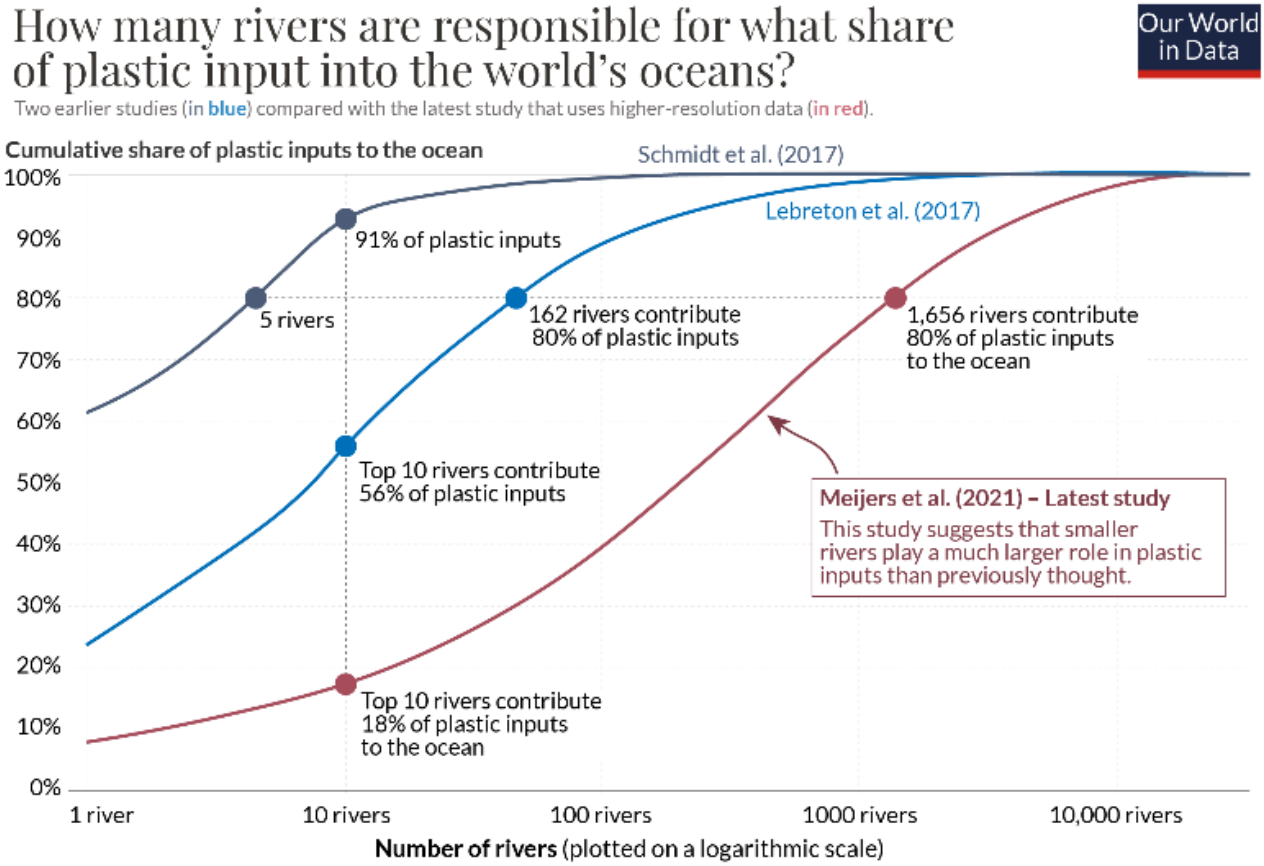


Figure 4-1 Share of plastic input from rivers into the world's oceans
Source: Schmidt et al. 2017; Lebreton et al, 2017; Meijer et al. 2021 (Graphics Source: Ritchie, 2021)

Despite such shift in the number of rivers and their contribution to plastics inputs to ocean, what does not change is the fact that majority of these rivers are from Asia. 81% of ocean plastics are emitted from Asia. All but one in the top 10 pollution countries and 43 of the top 50 polluting rivers are in Asia and the Pacific Seven rivers in the Philippines, the Klang (Malaysia) and the Ulhas and Ganges (India) are among the top ten rivers emitting plastics into ocean (Meijer et al. 2021). Asian rivers in China, Indonesia, Myanmar, Vietnam, Bangladesh, Thailand, Sri Lanka are also the locations of particular concern.

There are not only floating macroplastics in the rivers, presence of microplastics in the rivers have also been evident in few studies. Untreated wastewater laced with microplastics, and raw sewage is a key source of microplastics release into rivers. In the U.K., 130 microplastics particles per gram of riverbed sediment in River Tame was found (Woodward, et al. 2021). Microplastic survey of 33 samples along the Mekong and 6 samples in Agra and Allahabad, by CounterMEASURE Phase I out 36 of 39 samples contaminated with microplastics. Polypropylene (PP) found most in the Mekong. Polyethylene (PE) leading in Japan. 51 types of polymers found in River Yamuna in Agra. 80% of microplastics not known of source. The 2019's Sea to Source Expedition, from water samples taken from the Ganges, with the combined flows of the Brahmaputra and Meghna rivers, found potentially 1-3 billion microplastics per day were discharged just before it enters the sea in Bangladesh into the Bay of Bengal, during pre- and

post-monsoon seasons respectively. Of those microplastics, 91% were fibres, likely from clothing, and the remaining 9% were fragments (National Geographic, 2020).

Mismanagement of plastics waste including littering, low collection, open dumping, inadequate treatment, recovery, recycling, and inappropriate disposal is the main driver of plastics leakage to waterways. With a small proportion of leakage of plastics at the upstream through flood or washing away of pellets from factories, or accidental leakage (maritime accidents), most plastic leaks at the end-of-life stage. Religious tourism that usually involves performing worship, expressing gratitude, confess in, perform a vow, or commemorate and celebrate religious and cultural events in and around waterbodies are also responsible for plastics leakage to waterways.

Text Box 4-1 Cases of disposable plastics leakage during religious festivities

1. Fluvial parade/procession and plastics waste (the Philippines)

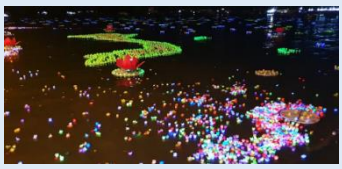
Any religious or cultural celebration and conglomeration in the Philippines uses colourful buntings (*banderitas*) that hang in rows along the streets. These *banderitas* are made of coloured glossy plastics/lobo for street decoration.

Held on the Saturday morning before the Sunday feast of the Santo Niño, the fluvial parade is an annual civic celebration that started in the early 1980's. For the *Fluvial parades/processions* not only the streets but also the boats/floats/andas/pagodas are decorated with these *banderitas*. These religious celebrations are also a source of plastic pollution as the plastics *banderitas* either directly ends up in rivers during the parade or discarded after the celebration. In addition, piles of single-use plastic food packaging also add to plastic waste and littering, as thousands of people flock to observe the parade. http://mycebuphotoblog.com/2020/02/10/fluvial-parade-2020-a-yearly-cebuano-tradition-you-shouldnt-miss/

2. Floating lanterns festivals – Loy Krathong (Thailand), Shwe Kyin Festival (Myanmar), Ghost Festival (Vietnam)

Many ASEAN countries celebrate this annual Buddhist festival that involves ritual offering into waterways. These ritual offerings involve many items made up of plastics that contributes to plastic pollution into waterways.

Loy Krathong (*Loy* means float (and *Krathong* means a small container) is celebrated on the evening of the full moon of the 12th month in the traditional Thai lunar calendar, Decorated baskets with 'light', incense, flowers and trinkets are floated on a river to pay respect and seek forgiveness from the Goddess of Water. This aesthetically beautiful festival is in the schedule of many tourists too. Traditionally, baskets made of biodegradable materials like banana leaves have been unfortunately replaced with Styrofoam (though lesser percentage) that is more buoyant and cheaper. These *Krathongs* are visually pleasing, usually clogs canals and add water pollution.

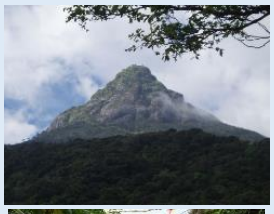


Lit-up lanterns are floated on Lan Ha off Hai Phong, northern **Vietnam**, on August 10, 2019 to celebrate Ghost Festival (observed on the 15th day of the seventh lunar month). Approximately, 30.000 plastic lanterns were released, which were later colelcted by the local Lan Ha Bay Authority (https://tuoitrenews.vn/news/lifestyle/20190827/buddhist-event-sparks-environmental-controversy-for-releasing-30000-plastic-lanterns-to-sea/51096.html)

3. Religious conglomeration & plastic pollution: Bishwa Ijtema and Turag River Pollution in Bangladesh

The Bishwa Ijtema, meaning "Global congregation", is one of the largest Muslim gatherings in the world. The gathering happens in Tongi, by the banks of the River Turag, in the outskirts of Dhaka, Bangladesh. Pilgrims stays at the riverside for 3-7 days. Garbage from devotees' cooking arrangement including plastic containers, cutlery, plastic bags leak to the river. Bishwa Ijtema festival is shown to have significant impacts on downstream river toxicity levels, impacted by garbage disposal, insufficient sanitary provisions. https://www.thedailystar.net/city/biswa-ijtema-2019-now-end-tuesday-1703473

4. Pilgrimage plastic footprint: Sri Pada, Sri Lanka



Sri Pada (Holy footprint) or Adam's peak is a sacred mountain in Sri Lanka, revered by Buddists, Hindus, Christians and Muslims. This sacred shrine is also the spring for major rivers in Sri Lanka. Plastic littering is a major problem, with both travellers and vendors throwing plastic bags, food wrappers and other trash over cliffs all over the mountain. The plastic and polythene get flushed to the rivers (**Kelani,** Kalu, Walawe, and Mahaweli, all which originate from Sri pada) during heavy rains. During the 2020/21 pilgrimage season, Eco Spindles and partners, Link Natural Product Private Ltd., Maskeliya Divisional Council, and the Nallathanniya Wildlife Department collected over 45,000 waste plastic bottles from Sri Pada. Corporates like Coca Cola, Clogard are working on creating awareness among pilgrims to minimize using plastic when travelling, as well as collecting thrown away plastics bottles from the Sri pada route. https://www.lankabusinessnews.com/clogard-helps-safeguard-the-river-roots-at-sri-paada/

5. Case of Pamba river pollution during (Sabarimala festival), in Kerala, India

Sabarimala temple dedicated to Lord Ayyappa is located on Sabarimala hill on the banks of the river Pamba and deep in the forest of Periyar Tiger Reserve in the state of Kerala, India. This pilgrim site is visited by an estimated 40-50 million devotees every year. About 35 million devotees visit the temple during the 60-day period of the pilgrimage from November 15 to January 15. Some devotees however stay on till January 20. Pilgrims visiting the temple take bath in the river which is believed to be equivalent to bathing in the Ganga River.

Plastic pollution is a huge issue for the site as these millions of visitors often throws plastics. Each person who goes to Sabarimala leaves behind at least 250 grams of plastic. An estimated million plastic bottles are thrown annually. The land is covered in plastic multilayer packaging and water bottles that make it into the Pamba river eventually. The extent of plastic pollution in the area is so much that many dead fauna (samba deer, elephant) were found to have traces of plastic in their digestive tracts.

From voluntary clean ups to Court's order, many initiatives are taken in addressing plastic pollution issue, from discouraging littering in Pamba river and requesting devotes to use biodegradable materials, handing clothe totes to devotees, to Kerala High Court's 2015 order on strict action against littering in the river, free water refill stations along the pilgrimage, cleaning up discarded clothes and plastics from the river, and ban on sale and use of plastic at Sabarimala.

https://earth5r.org/pamba-river-pollution-kerala-circular-economy/
https://www.thehindu.com/news/national/kerala/plastic-ban-to-be-total-in-sabarimala/article28191558.ece
https://www.business-standard.com/article/news-ians/mission-green-sabarimala-200-000-pilgrims-sign-pledge-to-keep-pamba-river-clean-116011700367_1.html

4.2 Potential increase in plastics leakage into waterways and rivers during COVID-19

The COVID-19 pandemic has changed our day-to-day habits and practices. The pandemic intensified the usage of single-use plastic prodcuts due to hygiene reasons (use of plastics-based mask, gloves), and disposable plastics packaging for food and grocery that arrived through e-commerce/home delivery channels. Preference of SUPP over reusables further undermined the sustainability and brought new types and more volume of low value plastics packaging indicating increased plastic litter. Disruption in regular waste collection, decline in recycling activities, low segregation of potentially infectious PPE waste from non-clinical setting such as residences, hotels, airports etc. meaning increased chances of direct disposal in waterways, rivers, or open dumping or landfills with leakage to freshwater and marine environment possible.

The pandemic brought compositional differences in territorial, riverine, and marine plastic pollution. A new type of plastics waste (PPE/mask) and unprecedented volume of disposable food packaging, especially, the food containers in our waste stream and into rivers and oceans was the change in plastic waste brought by the pandemic. In a 35-year of history, it was the first time that PPE was added in the beach litter category into Ocean Conservancy's Clean Swell mobile app in late July 2020, ahead of the 2020 International Coastal Clean-up (ICC). The extent of PPE pollution was so evident that in the 107,219 individual pieces of PPE were collected from beaches and waterways worldwide in second half of 2020 by the ICC volunteers. 94% of volunteers and coordinators surveyed found PPE at a clean-up in 70 out of 115 participating countries, and nearly 75%+ of PPE was reported as single use/disposable (Ocean Conservancy, 2021). PPE litter (disposable face masks, wipes, gloves) were reported to be found on streets, sidewalks, public parks, in waterways and the ocean in various clean up campaigns. The 2020 International Coastal Clean-up, 62,210 PPE items including discarded gloves and masks around the world out of over 1.5 million pounds of trash collected worldwide (Kavilanz 2020), clearly depicting the new reality of PPE wastes are the result of COVID-19 pandemic.

In 2019's coastal clean-up (Ocean Conservancy, 2020), for the first time in 34-years of Ocean Conservancy's beach clean-ups, food packaging outpaced the cigarette butts as the most number-one-reported item along beaches and waterways worldwide. Of 32.48 million pieces of the beach litter item picked, more than 4.7 million individual food wrappers were gathered as compared to 4.2 million butts recovered. Plastic cups and plates, plastic grocery bags, and plastic take-away containers made to the top ten beach litter item collected (Ocean Conservancy, 2020). New research also substantiated the finding that in terms of litter origins, take-out consumer items (mainly plastic bags and wrappers, food

containers and cutlery, plastic and glass bottles, and cans) made up the largest share across environments (from 50% to 88%), except for the open ocean, where most of the items resulted from ocean-based activities. The study was conducted in the seven major aquatic environments ranging from rivers to shorelines and the open ocean, and from the surface to the seafloor. In fact, plastic food containers and cutlery were the most-reported items found in river waters and were very common on shorelines (Morales-Caselles et al. 2021). With COVID-19, heightened use of food containers and cutleries and pre-packaged grocery items, the trend of finding food packaging litter in rivers and oceans seems obvious.

Increased presence of PPE items and disposable food containers in riverine environment is also substantiated by the plastics leakage hotspot survey conducted by the project on Promotion of Countermeasures Against Marine Plastic Litter in Southeast Asia and India ("CounterMEASURE"). Funded by the Government of Japan and managed by the UN Environment Programme's Regional Office for Asia and the Pacific, the CounterMEASURE project works to identify sources and pathways of plastic pollution in river systems in Asia, particularly the Mekong and the Ganges by deploying technologies like GIS, machine learning and drones to augment ground-level research in an efficient and scalable way. According to the macro-plastic survey conducted in the dry season in 2021 at 841 sampling sites (507 littering spots, 284 artificial barriers, and 50 uncontrolled dumpsites) across Mekong and Ganges rivers, takeaway containers made a top 3 plastic litter in most of these locations (**Table 4-1**). Facemasks were the most frequently found PPE waste with its presence in more than 50% of total sampling sites (especially at littering spots).

Table 4-1 Dominant plastics waste at multiple locations in Mekong and Ganges

Sampling location (sampling size)	Dominant plastic waste		
	Artificial barrier	Littering spot	Uncontrolled dump
Can Tho, Vietnam (104)	- **Containers** - Others - Beverage bottles - Grocery bags - Food wrappers	- **Containers** - Others - **Face mask** - Food wrappers - Grocery bags	- Other - **Containers** - Food wrappers - Grocery bags - **Face mask**
Phnom Penh, Cambodia (269)	- **Face mask** - **Containers** - Cups and plates - Food wrappers - Others	- **Face mask** - **Containers** - Cups and plates - Food wrappers - Beverage bottles	- **Containers** - Cups and plates - **Face mask** - Plastic bottles - Clothes
Tonle Sap, Cambodia (148)	- Plastic bottles - **Containers** - Food wrappers - Cups and plates - **Face mask**	- **Containers** - Diapers - Clothes - Food wrappers - **Face mask**	
Ubon Ratchathani, Thailand (103)	- Beverage bottles - Grocery bags - Other - Food wrappers - Plastic bottles	- Grocery bags - Other - Food wrappers - Beverage bottles - Clothes	- Cups and plates - Rope
Vientiane, Lao PDR (220)	- Beverage bottles - Grocery bags - Other - Cups and plates - **Face mask**	- Grocery bags - Other - **Face mask** - Beverage bottles - Cups and plates	

Text Box 4-2 COVID-induced plastics leakage in rivers and waterways

Leakage of COVID-waste into rivers, Cisadane River, Indonesia
Following the collapse of the wall of the Cipeucang landfill in late May 2020, 100 metric tons of waste including masses of used syringes, masks, gloves, hazmat suits leaked into Indonesia's Cisadane River. Locals are dependent on this 138 km long river to bathe and wash their clothes. Such leakage of infectious medical wastes puts residents under potential risk of transmission of COVID-19 and other health hazards. https://www.globalcitizen.org/en/content/covid-19-medical-waste-Cisadane-river/?template=next

PPE debris in river outlets into Jakarta Bay during COVID-19 pandemic
Compared to baseline date of 2016, riverine debris releases into Jakarta Bay in March and April 2020 during the COVID-19 pandemic were found to be increased. Plastics continued to dominate the river debris at 46% (abundance) or 57% (weight). PPE in the river debris has been found in abundance during the pandemic. Plastic-made personal protection equipment accounted for 15–16% of the collected river debris or 0.13 ± 0.02 tons (weight) daily. In March and April

2020, seven more types of medical waste (cotton mask, sponge mask, medical mask (surgical, N95), medical gloves, hazard suit material, face shield and raincoat as a substitute for hazard suit) were found. Masks (cotton, sponge and medical) represented only 9.83% of the total debris or 492 ± 99 items daily, remaining was dominated by PPE item. Source: Cordova et al, 2021

PPE waste wash up during floods

During the flood in Assam, India, discarded PPE kits, mask, blood pouches, syringes and other medical waste were washed amid floodwaters. Such incidents might also pose risks of virus spread from potentially infectious PPE and medical waste.
https://www.thehindu.com/news/national/other-states/concerns-over-covid-19-spread-as-discarded-ppes-masks-wash-up-in-assam-floods/article32125259.ece

PPE/mask on Soko beach Hong Kong

OceanAsia.org, during its survey trip to the Soko's islands found masses of surgical masks washing up on the shoreline. https://oceansasia.org/beach-mask-coronavirus/

Leakage of plastic pellets from sunken ship in Sri Lanka

In June 2021, the X-Press Pearl, Singapore-flagged cargo ship caught fire off the coast of Sri Lanka. Tons of plastic pellets/nurdles washed up on local beaches nearby. With 46 chemicals and acid, these tiny plastic pellets are the most visible sign of the cargo accident. Even though there is no concrete data, one estimate is that the cargo ship was carrying some 75 billion of these pellets.

Sri Lankan Navy cleaning the plastic pellets from the beaches near Negombo. They have so far collected more than 53,000 bags of pellets, burnt plastic and other debris mixed with sand.
https://www.unep.org/news-and-stories/story/oil-acid-plastic-inside-shipping-disaster-gripping-sri-lanka

The COVID-19 pandemic highlighted our relationship with single-use plastic products, vulnerabilities of our plastic waste management and recycling systems, and that our rivers and oceans are suffering collateral damage from the added plastic pollution load.

4.3 Initiatives taken to reduce riverine plastic leakage

Initiatives to reduce riverine plastic leakage requires holistic solutions addressing both upstream and downstream solutions including measuring and monitoring the plastic leakage into rivers, trash inceptors and river clean ups, and policy solutions. However, most of efforts are concentrated at downstream/post-disposal stage.

Interesting development has started in terms of using technology including Artificial Intelligence (AI), machine learning, robotics, GPS trackers, remote sensing, drones in river plastic mapping and analysis. River plastic monitoring is using the newest technologies to capture image sensors to monitor macroplastics, transport pathways and fate of the plastics in rivers and oceans. Technology and tools are being used to engage citizens for tracking river plastic debris, clean-up activities, and also to raise awareness on riverine and marine plastics pollution. These open-source technologies have gathered more value in the present time of COVID-19 pandemic, where mass gathering for community clean ups are restricted.

Text Box 4-3 Use of technologies in measuring and monitoring riverine plastics leakage

National Geographic's Sea-to-Source Ganges Expedition

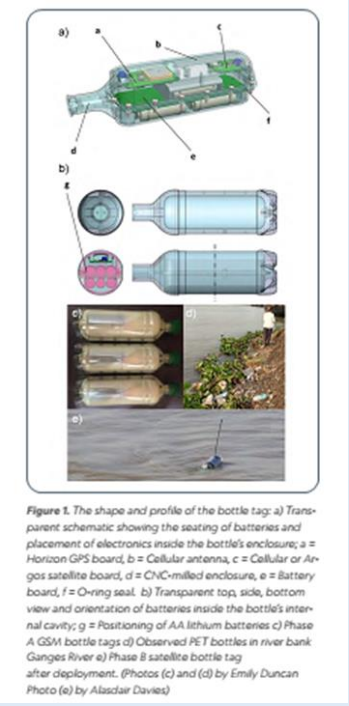


Figure 1. The shape and profile of the bottle tag: a) Transparent schematic showing the seating of batteries and placement of electronics inside the bottle's enclosure; a = Horizon GPS board, b = Cellular antenna, c = Cellular or Argos satellite board, d = CNC-milled enclosure, e = Battery board, f = O-ring seal. b) Transparent top, side, bottom view and orientation of batteries inside the bottle's internal cavity; g = Positioning of AA lithium batteries c) Phase A GSM bottle tags d) Observed PET bottles in river bank Ganges River e) Phase B satellite bottle tag after deployment. (Photos (c) and (d) by Emily Duncan Photo (e) by Alasdair Davies)

The 98-days expedition used various technology and tools tracking, measuring and monitoring the plastics waste.

Bottle Tag—Open-Source Tracking Technology, a satellite tracking tag, originally designed to track sea turtles, was into a 500 ml water bottle to track the movement of plastic pollution from the point it enters waterbody to its final destination. This open-source technology was designed by ZSL and Arribada. This method further helps answer the following research questions:

- How is plastic debris moving in space and time from rivers to the ocean?
- Where does plastic debris accumulate?
- What river/coastal/ocean habitat locations are vulnerable to degradation due to the presence of plastic accumulations?
- Where are potential hotspots and vulnerable areas from plastic debris accumulation that can be targeted for clean up?

As mobile phone networks were available (i.e urban areas), each bottle would transmit its GPS location and the team would record the location updates. Using Google Earth, the bottle is tracked taking notes of the path it would take next, which fork in the canal, which weir or barrier would halt it in its tracks etc. The bottle once reaches the open ocean and mobile phone reception is lost, and at this point the satellite transmitter would take over and transmit the bottle's location every three hours.
25 Bottle Tags were deployed during the Ganges expedition, and the plastic bottle were successfully tracked through the Ganges River system and into the Bay of Bengal. The maximum distance tracked so far has been 2,845 km over a period of 94 days, and some tags are still actively transmitting.

Debris Tracker App, an open-data citizen science tool, was used by the expedition to record geospatial data on inland and marine debris. Debris Tracker is an, powered by Morgan Stanley in partnership with the National Geographic Society and the University of Georgia. This free app is available on Android and iOS operating systems. During the Ganges expedition, 89,691 litter items were tracked using the Debris Tracker App.

The Sea to Source Expedition also trialled a **machine learning analysis** of 78,767 drone images taken from 42 flights along the riverbank at nine of the 11 sites. In the pre-monsoon survey, an average of 1.17 litter items per square meter were found. https://jambeck.engr.uga.edu/wp-content/uploads/2021/02/Sea-to-Source-Summary-Report.pdf https://jambeck.engr.uga.edu/wp-content/uploads/2021/02/Sea-to-Source-Methods-Toolkit.pdf

Technology and tools used by CounterMESASURE project to track riverine plastic pollution in Ganges and Lower Mekong

The project on Promotion of Countermeasures Against Marine Plastic Litter in Southeast Asia and India ("CounterMEASURE") in its phase I implementation in 2019 used a Geographic Information System (GIS) platform, and drones to visualize plastic leakage data and pathways. It also used mobile App as tool to engage citizen science into riverine plastic tracking and awareness raising. The mobile application is a convenient tool for cataloguing plastic leakage hotspot locations and recording relevant ancillary data related to them. Approximately 1,000 hotspot locations were collected and analysed along the lower Mekong River in Chiang Rai, Thailand; Vientiane, Lao PDR; Ubon Ratchathani, Thailand; Phnom Pen, Cambodia; and Can Tho, Vietnam. https://experience.arcgis.com/experience/f3313167d9084a6c88ad1bb4e46341ef/?org=gicait

The project in its Phase II is taking the technology use up by using citizen science and machine learning, with technical advisory support from Google. With Google's support, UNEP will create a new machine learning model that reveals a more detailed and accurate view of plastic pollution in the Mekong River. The machine learning model will strengthen the algorithm through community-sourced, annotated images, and contribute to the development of a plastic leakage hotspot map. The map can then be used by local and national governments to determine how to target policies and resources to prevent plastic leaking into waterways. https://youtu.be/vKwlo96Tddg?list=PLKdGlbtBVuW2Crf2j1dHaws7bwdg2K-cO

pLitter https://gicait.github.io/pLitter/#annotate is a standardized, deep learning-friendly image dataset and pre-trained model for roadside plastic litter identification, developed by the CounterMEASURE project. The dataset includes images of plastic littered scenes and annotations in COCO format. The main features of the dataset are Object detection, 10,000+ images, 50,000+ object instances, 4 object categories (Facial mask, Pile, Plastic, and Trash bin)

Plastic hotspots on Rayong beach, Thailand
https://countermeasure.asia/

Modern technologies have also been useful in intercepting trash from discharging into rivers and river clean ups. As rivers act as "highways" for plastic leakage into ocean, such trash interceptors also help collect plastics before it reaches the ocean. From simple plastic capture devices such as netted-mesh, trawlers, to boats, booms, receptacles for manual collection, there are many other creative inventions using for automated collection of garbage.

Text Box 4-4 Modern technology keeping plastics leakage into rivers at bay

The Interceptor extracts plastics from polluting rivers. The debris enters the Interceptor with the natural current of the river. The Interceptor consist of floating barriers attached to processing plants that resemble barges and are anchored to the riverbed. The barriers funnel plastic waste into the mouth of the plant. This automated machine is 100% solar powered, including the conveyor belt, shuttle, lights, sensors, data transmission, are solar-powered. A conveyor belt separates the waste from the water and moves it up to a shuttle, which automatically dumps the waste into containers on a separate barge docked below. As the Interceptors are internet-connected, they allow to gather continuous performance and collection data. It also enables the Interceptor™ to automatically notify local operators once the dumpsters are full. Under optimal operations, the Interceptor can extract 50,000 kilograms of plastic per day. Currently, the Interceptors are deployed in three rivers: Cengkareng Drain in Jakarta, Klang River, Malaysia (is among the 20 top ten polluting rivers, and Rio Ozama, Santo Domingo, Dominican Republic.

Ocean Strainer in Dehiwala channel, Sri Lanka
Sri Lanka launched its first floating trash trap Ocean Strainer, in the Dehiwela Canal in September 2020. The trash trap collects a minimum of 35 kg of plastic waste on a daily basis and controls the plastic waste leakage to the ocean. This pilot project was launched by MAS Holding together with the Marine Environment Protection Authority-Sri Lanka (MEPA), Western Provincial Council, Sri Lanka Land Reclamation and Development Corporation and the Environmental Police. https://www.newswire.lk/2020/09/14/watch-sri-lankas-first-floating-trash-trap-the-ocean-strainer/

Policy solutions to riverine plastic leakage are mostly a part of the legislation and regulations focusing on waste reduction, bans, fiscal incentives, and disincentives on littering, dumping, recycling and other voluntary initiatives and campaigns on waste management improvements. In addition, there are special initiatives from national and subnational governments, as well as non-governmental organizations as response to protection and restoration of rivers.

5. Recommended actions to confront plastic pandemic through responsible consumption behaviour, innovative technologies, and policy acceleration

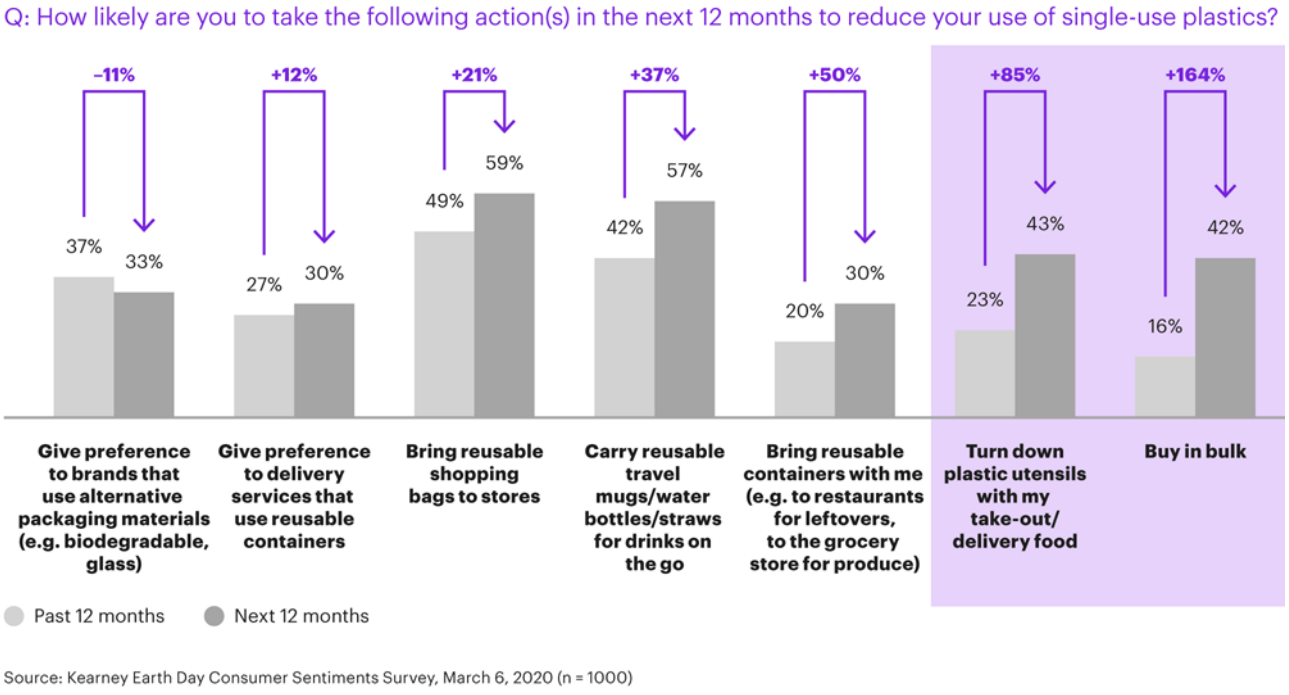
Myths exploited COVID-19 fear and falsely promoted SUPP safer than reusables, lack of clear message from government encouraging public to choose reusables made it further difficult to break free from our old habit and liking for disposable plastics. The pandemic also paused the policies and initiatives that were put in place to fight plastics pollution citing hygiene and safety as a reason. Nonetheless, the pandemic has also reiterated the role of smart and innovative technologies to rethink and optimise plastic consumption, in reducing unnecessary plastics through upstream design innovations, innovation in logistics and circular business models, improve plastic waste collection, safe handling, recycling and recovery.

5.1 Encouraging responsible consumption behaviour by addressing myth and misinformation on reusable plastics during the COVID-19 'infodemic'

While use of disposable plastic product and packaging even before the pandemic was already high, and people preferred those disposables for 'convenience' mainly. This pandemic however changed the sentiment of the public over plastics and the connotation that SUPP make product safe and hygienic providing vital protection from coronavirus and other infections. This sentiment is likely to stay, influencing SUPP consumption and the resultant plastics pollution.

The Earth Day Consumer Sentiments Survey conducted by the Kearney Consumer Institute on 6 March 2020 shows that that opting for reusables packaging, containers and cutlery and bulk buying to cut

down plastics packing seems to be consumers' efforts in reducing SUPP in coming 12 months (**Figure 5-1**).



Source: Kearney Earth Day Consumer Sentiments Survey, March 6, 2020 (n = 1000)

Figure 5-1 Likely actions to be taken by consumers to reduce single-use plastic products consumption: Response of the Earth Day Consumer Sentiments Survey conducted by the Kearney Consumer Institute

Another survey of 1,014 consumer in Canada (Kitz, 2021) studied the changes in Canadian consumers' attitudes toward SUP packaged foods, from Summer 2019 to Summer 2020 The results showed a growing willingness to pay for biodegradable alternatives, but a clear decline in support for tighter regulations or ban on SUPP. This could be because of an increased concern over increased importance of food safety concerns during the pandemic. On question asking respondents to rank the importance of new safety concerns during COVID-19, to their decision to purchase plastics packaged foods, 30% agreed (somewhat/strongly), 54% neither agree nor disagree, and 16% disagree (somewhat/strongly). Similarly, 52% agreed (somewhat/strongly), 20% neither agree nor disagree, and 28% disagree (somewhat/strongly) when asked 'I believe that any new regulations on single-use packaging in Canada should wait until after the COVID−19 pandemic is fully resolved.' While such consumer surveys give a perspective on what consumers think, but there is a huge gap between consumer attitude and intent. Also, these surveys were conducted in the early onset of pandemic when no one knew that the virus situation would no longer be in few hot spots but all over the world and will continue for long time.

It is important to find when and how the information on SUPP being safer than reusables did the rounds. One of the first communication in this regard came from a letter[24] sent by the American Plastics Industry Association on 18 March 2020 to the US Department of Health and Human Services suggesting SUPs is often the most sanitary choice for consumption and transport of food, whether purchased at a restaurant or at a grocery store. Quoting cases of businesses Starbucks and Dunkin Donuts suspending the use of reusable cups to prevent the spread of the coronavirus, and few city counties calling off plastic bag ban, the letter urging the Department to "make a public statement on the health and safety benefits seen in single-use plastics." The letter claim that reusable bags can carry viruses and bacteria, spread them throughout a grocery store quoting some past studies. One study 'Assessment of the Potential for Cross-contamination of Food Products by Reusable Shopping Bags' claims that bacteria were found in 99% of reusable bags tested, but none in new bags or plastic bags; Coliform bacteria were found in 51% of the bags tested, with generic E. coli in 8%; and hand or machine washing was reduced the bacteria in bags by > 99.9%. (Williams et al 2011).

This met an outcry from environmentalist and saw this as the plastics industry exploiting people's fears around COVID-19 and attacking reusable bags. As a counter to the claim that reusable bags and

[24] https://www.politico.com/states/f/?id=00000171-0d87-d270-a773-6fdfcc4d0000

tableware are unsafe, 125 scientists, academics, doctors, and specialists in public health and food packaging safety from 18 countries released a statement[25] noting that properly cleaning, sanitizing, and handling reusable food serviceware items allows the best control potential exposure.

There is no credible evidence of transmission of COVID-19 from food, food containers or food packaging, or e-commerce packaging, even though, the virus is expected to be alive for 72 hours on plastics as stated by the WHO,[26] the U.S. Food and Drug Administration[27], Food Standards Australia[28], among others. The three scientific studies highlighted in the Plastics Industry Association's letter claim that reusable grocery bags place people at substantial risk to COVID infection and SUPP is safer are of questionable applicability (Hale and Song, 2020). PPE (made up of disposable plastics) is more of necessary item as it reduces airborne transmission of coronavirus. Nevertheless, PPE are the most visible pandemic waste, and its improper disposal has led to increased littering and leakage putting both health of the public and the environment at risk. Although reuse of healthcare plastic (including PPE) is possible after careful disinfection and sterilization, reuse is not a prescribed option amidst COVID-19 unless it's a case of critical shortages. Reprocessing of used PPE through various decontamination techniques and reuse of PPE is seeing some developments. The common reprocessing technology across these sterilization industries is use of hydrogen peroxide in vapour state (VH_2O_2) for PPE treatment. There is still a greater need to develop trust and confidence in reuse of PPE by health care waste that can be addressed through engagement in social marketing and knowledge sharing (Rowan and Laffe, 2020).

One of the most used PPE is the facial masks, and despite guidelines there still is confusion on the use of correct types of masks, and questionable clarity on the reusable masks. Whilst there are some guidelines and studies on the efficacy of reusable mask and who and when to wear reusable masks versus medical or disposable masks, these messaging have not been properly disseminated, indicating the need for more such messages to be circulated, ideally, through social media network that out the fastest and wider outreach. Nonetheless, utmost care must be given to use social media to relay the evidence-based information and correct message as misinformation thrives in these social networks.

The unknowns about the 'new' disease, fear, anxiety and panic proliferated disinformation and myths surrounding COVID-19 transmission and cure were all around the media, causing overabundance of information causing 'infodemic.' Media, especially, social media networks became a breeding ground of false information. According to Islam et al. 2020, from the information was extracted from fact-checking agency websites, Facebook, Twitter, and online newspapers, and their impacts on public health between December 31, 2019, and April 5, 2020, 2,311 reports of rumours, stigma, and conspiracy theories in 25 languages from 87 countries. Most of the rumours were related to COVID-19 illness, transmission and mortality (24%), treatment and cure (19%), cause of disease including the origin (15%), violence (1%), and miscellaneous (20%). Most of the rumours, stigma, and conspiracy theories were identified from India, the United States, China, Spain, Indonesia, and Brazil.

There have been a few initiatives have been breaking the chain of disinformation. The WHO has a dedicated webpage page for Mythbusters[29] covering a vast range of topics. Similarly, the collaboratium for social media and online behavioural studies[30] has developed a webpage on fact checking the myths and misinformation circulating online. Global Media broadcaster like CNN[31], is also publishing Q&As regarding COVID-19.

[25] https://www.greenpeace.org/static/planet4-international-stateless/2020/07/0c3a6a32-health-expert-statement_updated.pdf
[26] https://apps.who.int/iris/bitstream/handle/10665/331705/WHO-2019-nCoV-Food_Safety-2020.1-eng.pdf
[27] https://www.fda.gov/food/food-safety-during-emergencies/food-safety-and-coronavirus-disease-2019-covid-19
[28] https://www.foodstandards.gov.au/consumer/safety/Pages/Can-COVID-19-be-transmitted-by-food-or-food-packaging.aspx
[29] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters
[30] https://cosmos.ualr.edu/covid-19
[31] https://edition.cnn.com/interactive/2020/health/coronavirus-questions-answers/

Text Box 5-1 Attempts to demystify myths about PPE

Demystifying myths about masks

- During the initial period of COVID-19 outbreak, and lack of clear guidance and studies showing the efficacy of reusable and fabric masks, medical mask faced hiked price, and stock shortage in the market. For example, during the 1st and 2nd Coronavirus outbreaks in Vietnam, price of medical face masks increased by 3-5 times, sometimes up to 30 times (Luat and Hai, 2020; Tri, 2021), and increased use of disposable masks while it was not necessary. This issue was later resolved to a large extent after the Ministry of Health of Vietnam issued Decision No. 1444/QD-BYT (dated March 29, 2020), providing temporary guidance on the selection and use of masks in the prevention of COVID-19 epidemic. 3- or 4-layer cloth face masks or washable antibacterial cloth masks are encouraged to be used by healthy people who work and live-in areas with a low risk of Covid-19 infection (Nguyen, 2020).

- WHO page "*Coronavirus disease (COVID-19) advice for the public: When and how to use masks*" provides updated information on mask use provides a lot of information, with clear infographics, videos, Q&A on specifics on what type of mask to be used, and also a 1-hour WHO course on when, where and how to wear a mask in community settings. The WHO with the UK government has also launched a global campaign "Stop The Spread" to raise awareness about the risks of misinformation around COVID-19, and encouraging public to double check information with trusted sources such as WHO and national health authorities. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/when-and-how-to-use-masks

Breaking away from unnecessary PPE items

- The NHS, UK doctor uses TikTok to educate disposable gloves is not necessary for public while going out as it may rather increase the chance of chance of virus spread as germs accumulate on gloves as people will not wash hands as they acquire a false sense of protection with gloves. https://www.republicworld.com/entertainment-news/whats-viral/coronavirus-nhs-doctor-shows-danger-of-wearing-gloves-in-tiktok-video.html

- The U.S. Centre for Disease Control CDC also does not recommend using plastic face shields for everyday activities or as a substitute for face masks, except for those who are hearing-impaired and rely on lip-reading or those who have physical or mental health conditions that would be exacerbated by wearing a cloth face mask. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover-guidance.html

Comparatively, while there are fact-checking/myths busting webpage on COVID-19 relation information on illness, treatment and cure, and partially on the use of PPE/mask, there is very little to no information on myths busting around disposable plastics packaging. Upstream, Break Free from Plastics are some of the initiatives that are relentlessly promoting reusables even before the pandemic. During the pandemic they are creating FAQs, blogs on their website on reducing SUPs during the pandemic and messaging that reusable food containers, cutleries and grocery bags are still safe to use during the pandemic after following proper washing, cleaning and sanitizing protocols.

Text Box 5-2 Attempts to demystify myths about reusable plastics

Upstream® a public-interest, non-profit organization founded in 2003 by a group of Zero Waste activists in the US and Canada. It works in ideating, co-creating and accelerating real-world practical solutions to plastic pollution and today's throw-away culture. During the COVID-19 pandemic, UpStream has been featuring information (as blogs, podcast, FAQs etc.) on safe use of reusables on their website to encourage people to use reusables instead of unnecessary SUPs.

- Reuse vs Single-use: Safety: https://upstreamsolutions.org/reuse-vs-singleuse-safety
- Spread Facts, Not Germs: https://upstreamsolutions.org/blog/spread-facts-not-germs
- Myth-busting with public health experts: The safety of single-use (podcast): https://upstreamsolutions.org/podcast/myth-busting-with-public-health-experts

#**breakfreefromplastic** is a global movement envisioning a future free from plastic pollution.https://www.breakfreefromplastic.org/2020/03/26/plastic-pollution-reuse-and-covid-19/

In addition to current efforts, there still are a lot of scope and necessity to debunk myths surrounding SUPP being more sanitary than reusables during the pandemic and promote facts and option for practicing reuse and alternative materials. Dissemination of well researched and factual information designed with powerful messaging and delivered via multiple channels including social media is necessary to spark behaviour changes towards responsible consumption related to use of SUPP including correct use, sanitation, collection, safe disposal, and the prevention of littering during the pandemic.

5.2 Boosting innovative technologies, circular business model solutions

During the COVID-19 pandemic, though mostly at research and prototype phase, on a small scale, and efficacy of many of these innovation needs to be validated though controlled trials and are available for commercial consumption, new innovations are making their way. Waste management service providers, recyclers, food servicing industry and online delivery platforms are trying to innovate and adopt creative ways to both remain in the business and care for the environment and trying to find a balance hygiene and sustainability.

Text Box 5-3 Innovative solutions to reduce disposable plastics during COVID-19 pandemic

Material and design innovation around PPE

- Hemp mask by French company Geochanvre[32]
- AirX - coffee based mask by Vietnamese company ShoeX[33]
- Plastic-free visors by A Plastic Planet with Reelbrands and Transcend Packaging - made from FSC paper board and PEFC cellulose from wood pulp – is recyclable and home compostable. Plastic Planet has teamed with TerraCycle to collect visors from dedicated disposal bins to be recycled or composted[34]Compostable nonwoven sheet made from BioPBSTM[35]
- A Swiss company developed a livinguard promask[36] a fabric mask that is scientifically proven destroy >99.9 % of the exhaled SARS-CoV-2 viruses. The company also offers a surgical face mask model according to standard EN 14683:2019, which can be washed up to 30-times and replaces 210 disposable masks (with weekly washing).
- ReGlove[37] is a smart system that produces recyclable single-use gloves as a sustainable alternative to disposable plastic gloves. Built on creating a circular model, ReGlove reduces disposable plastic gloves ending up in landfills. Made out of polyvinyl alcohol (PVA), a water-soluble polymer, ReGloves can be easily repurposed into new gloves by simply dissolving the gloves in water, and autoclaving (sterilisation method that uses high-pressure steam) to remove contaminants.

Food servicing cafes/restaurants accepting reusable cups and containers

- The #ContactlessCoffee is a campaign by an environmental organization City to Sea to in the UK, to help keep reusable coffee cups on the menu. The participating cafes allow customers to bring reusable coups. The clean reusable cup (lid off) is placed on a designated spot on the counter or a tray, and steps back two metres. The barista extracts the coffee into a normal crockery cup and without touching the customer's reusable cup, the attendant pours the coffee into the customer's cup, and then steps back two metres for the customer to collect. https://www.citytosea.org.uk/contactless-coffee/

- Singapore, three main online food delivery (OFD) firms — Foodpanda, Deliveroo and GrabFood have partnered with two food container sharing services (Muuse and BarePack) to offer customers to opt for reusable food containers instead of disposables from the barePack and Muuse participating food outlets. Both reusable container rental companies offer subscription service to customers. These three OFD platforms signed an industry commitment to WWF PACT[38] with a mission to reduce single-use plastics, with a target of eliminating all unsustainable plastic packaging by 2024. Their first initiative involved an automatic opt-out toggle for plastic cutlery, saving over 1 million disposable utensils per week.

Travel and tourism sector fighting SUPs amidst COVID-19

- The Civil Aviation Administration of China on 26 May 2021 announced that China will ban the use of disposable plastic packaging bags, tableware and straws on domestic flights starting 2022. The ban will be extended to all airports and international passenger flights in 2023. http://www.xinhuanet.com/english/2021-05/26/c_139970492.htm

- Indian Railway replaces disposable plastics cups for tea with earthen cups (*Kulhads*). At presents 400 railway stations sells tea in earthen cups, which will be expanded to at all railway stations in the country as a contribution of the Railways towards a plastic-free India. The Indian Railway has also placed other measures to reduce, recycle and dispose plastic waste generated in stations in an eco-friendly manner. 315 plastic bottle crushing machines (PBCMs) have been installed at 229 stations by Zonal Railways.

https://economictimes.indiatimes.com/industry/transportation/railways/indian-railways-goes-eco-friendly-replaces-plastic-cups-with-kulhad/plastic-free-india/slideshow/79527039.cms
https://www.deccanchronicle.com/nation/current-affairs/130618/railways-show-the-way-to-crush-plastic-bottles.html

[32] https://www.reuters.com/article/us-health-coronavirus-france-hemp-mask-idUKKBN2621Z2
[33] https://www.greenqueen.com.hk/vietnamese-company-creates-world-first-biodegradable-coffee-face-mask/
[34] https://www.edie.net/news/5/World-s-first-plastic-free-PPE-equipment-launched-to-combat-coronavirus-pandemic/
[35] http://www.pttmcc.com/new/news-detail.php?id=96
[36] https://livinguard.com/promask/#
[37] https://theindexproject.org/award/winnersandfinalists/reglove
[38] https://plastic-action.asia/wp-content/uploads/2020/08/PACT-Impact-Report-Final.pdf

- Despite COVID-19 crisis, 32 new signatories from 20 countries onboarded the Global Tourism Plastics Initiative (GTPI). These include 14 accommodation providers and 6 tour-operators organizations representing the tourism value chain. The implementation of the Initiative is supervised by The World Tourism Organization (UNWTO) and UN Environment Program (UNEP) in collaboration with the Ellen MacArthur Foundation[39]. Travel without plastic (TWP)[40] is one of the first signatories of the GTPI. These signatories have set concrete targets and actionable plan for eliminating unnecessary single-use plastic items and transitioning to reusable alternatives by 2025. https://www.oneplanetnetwork.org/global-tourism-plastics-initiative-welcomes-32-new-signatories

- The DoubleTree by Hilton and the Pan Pacific Group in Singapore that offered service as quarantine hotels attempted sustainable options like using laundry bags made from Hydropol™ replacing the disposable plastic laundry bags. The sealed laundry bags like Hydropol™ also help reduce the risk of cross-contamination of COVID-19 to housekeeping and laundry staff as these can be put directly into industrial washing machines (without debagging). The Hydropol™ bags completely dissolve on an 80°C wash cycle and biodegrade safely in the wastewater system. Hydropol™ applications have a wide range from laundry bags to grocery bags, bin liners, PPE, gloves, apron and others. https://www.aquapakpolymers.com/laundry-bag-case-studies/

- To mark Maha Kumbh 2021 clean and polythene free, 'Paryavaran Committee (Paryavaran Samiti) 2021[41]' has been formed with an aim to make the Kumbh polythene free by using the concept of Eco bricks formation. This will require pilgrims to collect single-use polythene bags, plastic bottles, make Eco bricks. One Eco brick can carry 350-gram plastic that can otherwise litter 100 Sq Ft area. Polyethylene bags are the most common plastic garbage during Kumbh celebration. https://paryavaransanrakshan.org/wp-content/uploads/2021/02/Polythene-Mukt-Kumbh.pdf

Tea for Trash, Brooke Bond Red Label set up the first-of-its-kind tea vending machines across Kumbh Mela in 2019. Every time a pilgrim disposed off plastic waste, the sensor got activated and released a cup of tea from the tea vending slot. Such Tea for Trash vending machines collected 93 tonnes of garbage. https://www.arshiajain.com/tea-for-trash

Plastic pollution awareness at Kumbh: Rohitansh Sharma aka 'Plastic Baba' at Kumbh Mela in Allahabad in 2019 chooses this holy congregation as a place to create mass awareness against plastics. He and his volunteers collected more than 250 kg of plastics from Ganges and Kumbha area and handed over the recyclable plastics to local scrap dealer. https://timesofindia.indiatimes.com/city/allahabad/plastic-babas-satyagrah-against-plastic/articleshow/68262033.cms

Reuse business models for reducing unnecessary single-use plastics packaging

During COVID-19 a few social start-ups have started on-the wheel refill delivery at doorsteps minimizing last miles delivery packaging waste.

Siklus (means "cycle" in Bahasa Indonesia), launched in 2019, in Jakarta, aims to reduce the number of products packaged in sachets, by delivering everyday household essentials – dishwashing liquid, soap at doorstep allowing refilling, hence cutting down disposable plastics packaging. https://www.siklus.com/

Innovation in reusable retail bags

As much as the COVID-19 pandemic caused stir over banning of reusable grocery bags, the discussion has also got into innovating bagless retailing or innovative reusable bags. The Beyond the Bag challenged joined by the retailer giants Walmart and Target among other retailers, called for extraordinary ideas from all around the world seeking solutions centred around novel technologies that minimize or eliminate the need for bags altogether, including reusables and new materials, and leveraging the internet of things to connect customers to circular bag systems in-store or at home. 9 out of 455 submissions have been selected as winners. Winners will receive a portion of $1 million in non-equity funding and are eligible for additional funding and support from Consortium Partners to help with testing, piloting and scaling efforts. https://www.openideo.com/content/beyond-the-bag-challenge-winners

Innovation: reproposing plastics bottles from quarantine centres

The Tuticorin Corporation, India reused the plastic bottles waste generated from State-run COVID-19 quarantine facilities in building a toilet. 1,700 water bottles were washed, disinfected and filled with sand from seashores to build the toilet for sanitation workers working at Perumalpuram micro compost centre in the city. The toilet was built in one-third of the cost of budling a concrete toilet.http://timesofindia.indiatimes.com/articleshow/78930275.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Recycling PPE waste

- The supermarket chain Carrefour in Belgium has started a partnership with TerraCycle and Suez to recycle discarded single-use masks. Customers can drop off their used masks in a dedicated box at the supermarket entrance. Afterwards, TerraCycle cleans and processes the collected masks into granules to manufacture garden equipment, such as outdoor furniture, watering cans, garbage bins, construction tubes, etc.
https://www.carrefour.com/sites/default/files/2020-09/Alerte%20Presse%20-%20Recyclage%20masque%20-%2020.09.2020_fren.pdf

[39] https://www.oneplanetnetwork.org/sustainable-tourism/signatories-global-tourism-plastics-initiative
[40] https://www.travelwithoutplastic.com/
[41] https://paryavaransanrakshan.org/wp-content/uploads/2021/02/Polythene-Mukt-Kumbh.pdf

- The 'Recycle Man of India' and featured in the Forbes '30 Under 30' Asia 2018 list of successful social entrepreneurs, India, Binish Desai, 27, the founder of Eco-Eclectic Technologies, is recycling discarded PPE into Brick 2.0. The light grey bricks consist of 52% plastic waste (including mask, gloves and suits), 40% paper mill waste and 8% of the binder gum sap called chitin. Brick 2.0 is said to be three times stronger than any red bricks. It adheres nicely to the plaster, is lighter, recyclable, and costs half as much as the conventional bricks.





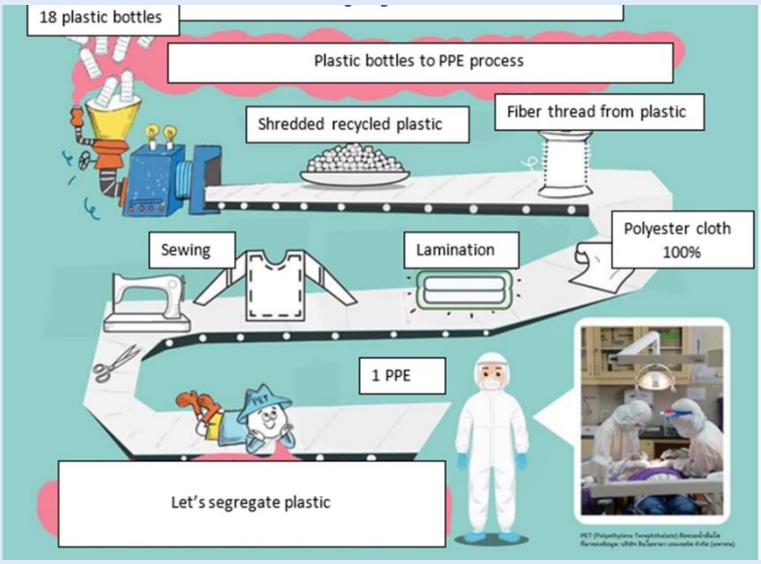
- https://timesofindia.indiatimes.com/city/mumbai/mumbai-discarded-ppe-suits-masks-repurposed-into-eco-friendly-bricks/articleshow/84253385.cms
- https://www.hindustantimes.com/trending/meet-the-recycle-man-of-india-turning-used-ppe-kits-and-masks-into-bricks-101627290434521.html

Digitization, frontier technologies to improve collection, repurpose and recycling of COVID-waste

Digitalisation, and frontier technologies like AI, machine learning, robotics are making their way in waste management sector too. With the contagious diseases like COVID-19 pandemic, using contactless and automated garbage collection, disinfection, automated sorting, improving recycling operational efficiencies and safety of waste workers, and river and ocean plastic debris clean-up has garnered interest.

Thailand converting Polyethylene terephthalate (PET) bottles into Personal protective Equipment (PPE)

The ***Yaek Kuad Chuay Mor*** (recycling PET bottles for doctors) is a campaign run by by the Less Plastic Thailand (https://www.lessplastic.info/) and its alliances. Kicked off in 2020, the campaign is on its fourth edition and will continue until 25 Dec 2021. In its first edition, the project back then imported recycled fibre from Taiwan and made 5,000 PPE suits for frontline medical workers across the country. By the end of its third edition the initiative has donated 24,000 PPE suits to healthcare providers nationwide. The PPE suits made by this recycling method are reusable around 20 times. In its 2nd and 3rd edition, PET bottled donated by public were converted into PPE suit in Thailand as the campaign was joined by a local recycling factory - TARF Company Limited. There are many PET bottle drop off points located across Bangkok such as Siam Paragon, the Panyapiwat Institute of Management, Get Well Zone shop on Ekamai 26, PTT Station Vibhavadi Rangsit branch, PTT Station Vibhavadi. Used PET bottles can also be mailed to Yaek Kuad Chuay Mor project, TARF Company Limited (waste management building), in Samut Prakan province.



Students at the Asian Institute of Technology (AIT) donated 19 kg of plastic bottles collected at the campus to the "Yaek Kuad Chuay Mor" project. It approximately takes 18 PET bottles to produce 1 PPE suit m for PPE production.

https://www.bangkokpost.com/life/social-and-lifestyle/2162943/make-plastic-fantastic

https://www.lessplastic.info/news; http://www.tarf.co.th/

Innovation and acceleration of upstream innovative solutions, to design plastic packaging and products by eliminating unnecessary plastics, designing plastics-based products with alternative materials, design for multiple reuse and recyclability, and keeping materials in circulation through reuse business models, as well as digitalization, use of AI and robotics and other touch-less technologies to collect, sort, and recycle potentially infectious pandemic waste is the way to transition to plastics circularity faster and more efficiently.

5.3 Spurring policy acceleration to reduce disposable plastics, promote reusables, and increase recycling

Policy enablers to encourage proactive steps and emerging innovations towards single-use plastic waste reduction, recycling and recovery and proper management of pandemic waste is critical. Unfortunately, during the initial period of the COVID-19 onset, many city authorities suspended the ongoing regulation or initiatives on banning or regulating the use of SUPP and promoting reusables over concern of hygiene and safety. This spurred the use of disposable plastics in one hand and on the other had with recycling facilities faced temporary shutdown due to cash flow crunch, human resources challenges and many other operational difficulties. Nevertheless, there are some cases of bold policy decision and declarations that came to ditch disposables and promote reusables, a midst pandemic uproar. It is these kinds of policy momentum that is required across countries to restart the pause on fight on SUPP during the pandemic.

Text Box 5-4 Examples of policy & practices reducing disposable plastics, promoting reusables and recycling

Bold policy in favour of banning SUPP amidst COVID-19

- Amidst COVID-19, the SUPD come into force on 3 July 2021. EU dismisses the European Plastics Converters (EuPC), a trade association called to lift ban on single-use plastics[42]. In an open letter (dated 8 April 2020)[43], EuPC asked for the postponement of the deadline for the implementation of the Single-use Plastic Directive (SUPD) for at least an additional year at national level and to lift all bans on some of the single-use plastics items. The SUP Directive, adopted in June 2019 SUPD targets the 10 most littered items found on Europe's beaches and seas, including food and beverage packaging. This new Directive bans food and beverage containers made of expanded polystyrene from July 2021. It also requires Member States to achieve ambitious and sustained reduction in the consumption of single-use plastic food containers by 2026.
- Colorado Governor signed the House Bill 21-1162[44] on 6th July 2021, banning single-use plastics (single-use plastic bags from grocery stores and retailers, and Styrofoam to-go containers used in the restaurant industry) despite opposition from the business community. Beginning in January 2023, the new law requires a 10-cent carryout bag fee, followed by a plastic bag prohibition starting in January 2024.
- Mexico City from 2 Jan 2021 announced a broad ban on single-use containers, forks, straws[45].
- Penang State Government, Malaysia announced No Plastic Bags campaign in supermarkets and hyper malls on Monday, Tuesday and Wednesday, and rest of the Thursday through Sunday, consumers have to pay RM1 for every plastic bag Penang Island Malaysia[46].

Governments promoting reusables masks during the initial months of the pandemic

- During the Press conference on 6 May 2020, the Hong Kong government announced to hand out 7 million washable masks CuMask that can be reused up to 60 times and more than 30 million disposable masks to local residents all for free. CuMask, was developed by the Hong Kong Research Institute of Textiles and Apparel. https://global.chinadaily.com.cn/a/202005/06/WS5eb2245ea310a8b241153972.html
- Japanese Prime Minister announce don 2 Apr 2020 that the government will distribute reusable cloth face masks to roughly 50 million households as stocks of disposable masks have run out at drugstores and other shops amid the coronavirus outbreak.https://www.japantimes.co.jp/news/2020/04/02/national/japanese-government-distribute-two-masks-per-household-abe/

Government's bailing out the recycling facilities

Hong Kong government offered two major subsidy schemes for recycling facilities that are currently financed by its recycling fund:

- One-off Recycling Industry Anti-Epidemic Scheme (ORIAS): support recycling facilities' operational costs by providing HK$ 20,000 every month.
- One-off Rental Support Scheme (ORSS): covers recycling facilities' rent either by 50% or up to HK$ 25,000

https://hongkongfp.com/2020/06/21/coronavirus-how-hong-kongs-dramatic-drop-in-recycling-sets-a-dangerous-new-norm/

The COVID-19 temporarily overturned the SUPP regulations; however, it also provided an extended view on the complexity and the widespread nature of plastic pollution, and a possible 'window of opportunity' to encourage governments, industry, and communities to work together through driving policy change and enforcement. The pandemic has highlighted that plastics pollution is an urgent issue and it is the time for national and international policy to be ambitious and support innovation and scale up actions that help reduce plastic waste generation and reduce plastic pollution in waterways and oceans. It is time to restart the pause button and hit the road to plastic sustainability through promoting responsible consumption behaviour, technological innovations, and policy acceleration to foster a robust recovery from the current plastic pandemic.

[42] https://www.euractiv.com/section/circular-economy/news/eu-dismisses-industry-calls-to-lift-ban-on-single-use-plastics/
[43] https://fd0ea2e2-fecf-4f82-8b1b-9e5e1ebec6a0.filesusr.com/ugd/2eb778_9d8ec284e39b4c7d84e774f0da14f2e8.pdf
[44] https://coloradonewsline.com/briefs/ban-on-single-use-plastics-polystyrene-signed-into-law-in-colorado/
[45] https://phys.org/news/2021-01-mexico-city-single-use-plastics-effect.html
[46] https://pgc.com.my/2020/beat-plastic-pollution/no-free-plastic-day-campaign/

6. Conclusions

The spike in the consumption of disposable plastics for food packaging and PPE items during the COVID-19 pandemic has increased plastic pollution globally. This shift in consumption trend is attributable to consumers anxiety over the coronavirus transmission and the strengthened 'safety & hygiene' fuelling use of more disposable plastics packaging and products. Further to the increase of low recycling value and potentially infectious SUPP, the COVID-19 pandemic disrupted the recycling activities. During the initial phase of the pandemic, a sharp decline in oil prices caused the global plastic industry to suffer, as recycled plastic was not price competitive to virgin plastics. Littering and leakage of disposable plastics, food containers, masks, gloves hence became a clear sign of pandemic-induced plastic pollution. The pandemic also altered the SUPP policy landscape, wherein regulatory ban and economic disincentives over single-use plastic products were suspended temporarily. Many businesses discontinued their reusable packaging systems - reusable grocery bags, reusable food containers as a precaution due to hygienic concerns. Though temporarily, such pause on SUPP ban policy has a risk of delaying and derailing the efforts made so far. It is also likely that the lifestyles and consumption patterns and policy relaxation towards SUPP may last even after the pandemic is over, which will be detrimental to the environment.

COVID-19 pandemic signified the need for sustainable, nature-based approaches with better urban land-use planning and health preparedness against such disasters. Innovative technology in the coastal megacity model could be introduced to provide vital services and sustainable integrated waste management. This will strengthen and enhance their preparedness against such events in the future. A few lessons learning from this pandemic to getting prepared for any potential future pandemics directs us to rethink and optimize the current unsustainable plastic consumption and fight the SUPP pollution with innovation, education, and regulation:

- Raising awareness to consumers and debunking myths around safety concerning reusable plastics, and encouraging responsible use of plastics

- Innovating to redesign plastic products and packaging by eliminating unnecessary and hard to recycle plastics, balancing both hygiene and sustainability

- Accelerating and readjusting of existing plastics policies to take more comprehensive attention and actions towards minimizing SUPP, providing financial triggers to facilitate circular economy approaches, enabling plastics recycling, and strengthening waste management systems and infrastructure

The COVID-19 pandemic has been a wake-up call for the Asia and the Pacific region to resume its efforts on SUPP minimization, promoting the reuse economy, and safely operating plastics recycling to combat marine plastic pollution.

References

Abdullah, Z. (2020). *Growth in food delivery business not enough to cover transport decline amid COVID-19 outbreak, says Grab Singapore head*. 11 June. Channel News Asia. Retrieved from: https://www.channelnewsasia.com/news/business/COVID-19-grab-food-growth-orders-transport-business-12825294

ADB. (2020). *Managing infectious waste during the COVID-19 pandemic*. Retrieved from: https://www.adb.org/sites/default/files/publication/578771/managing-medical-waste-covid19.pdf

Arbi, I.A. (2020). *Grab reports rise in deliveries, tipping during outbreak.* 5 May. The Jakarta Post. Retrieved from: https://www.thejakartapost.com/news/2020/05/05/grab-reports-rise-in-deliveries-tipping-during-outbreak.html

Arora, K. (2020). *Post-COVID 19 lockdown forecast for the informal recycling sector and suggestive interventions to help in the long term.* 11 May. Global Alliance of Waste Pickers. Retrieved from: https://globalrec.org/2020/05/11/post-COVID19-lockdown-forecast-for-the-informal-recycling-sector-and-suggestive-interventions-to-help-in-the-long-term/

Australian Bureau of Statistics. (20201). *Retail Trade, Australia - Monthly and quarterly estimates of turnover and volumes for retail businesses, including store and online sales.* Reference period January 2021. Retrieved from: https://www.abs.gov.au/statistics/industry/retail-and-wholesale-trade/retail-trade-australia/jan-2021#analysis-by-industry

Bangkok Post (29 Apr 2021). *Fear over sloppy mask disposal.* Retrieved from: https://www.bangkokpost.com/thailand/general/2107343/fear-over-sloppy-mask-disposal

Benson, U., Bassey, D.E, and Palanisami, T. (2021). COVID pollution: impact of COVID-19 pandemic on global plastic waste footprint. *Heliyon,* Volume 7, Issue 2, 2021.

Bloomberg. (2020). *China's war on garbage faces a major coronavirus setback.* 2 April. Bloomberg News. Retrieved from: https://www.bloombergquint.com/business/china-s-war-on-garbage-faces-a-major-coronavirus-setback

Boroujeni, M., Saberian, M., & Li, J. (2021). Environmental impacts of COVID-19 on Victoria, Australia, witnessed two waves of Coronavirus. *Environmental Science and Pollution Research,* 28(11), 14182-14191

Bose, M. (2020). *Coronavirus: 25 lakh COVID-19 protective gears needed every day, say experts*. 4 May. Deccan Herald. Retrieved from: https://www.deccanherald.com/national/west/coronavirus-25-lakh-COVID-19-protective-gears-neededevery-day-say-experts-833332.html

CGTN. (2020). *Hong Kong plastic waste: Food delivery and takeouts bring surge in plastic pollution.* 28 September. CGTN. Retrieved from: https://news.cgtn.com/news/7a497a4d33514464776c6d636a4e6e62684a4856/index.html

Chang, H.H. and Meyerhoefer, C.D. (2021). COVID-19 and the demand for online food shopping services: Empirical evidence from Taiwan. *American Journal of Agricultural Economics* 103(2), 448-465.

Charles D., Kimman L., and Saran, N. (2021). *The Plastic Waste Makers Index*. The Minderoo Foundation.

Chen, K. (2020). *Worried about Buying More? During the Epidemic, Taiwanese People Often Shop Online*. Kantar Report on COVID-19. Retrieved from: http://tns-global.com.tw/MailSources/InfoPulse/2020/COVID-19/Kantar_Taiwan_COVID-19_Report3_ecommerce.pdf (in Chinese)

Chern, K.W. (2020). *Southeast Asia sees big shift to e-commerce during COVID-19*. 21 October. Myanmar Times. Retrieved from: https://www.mmtimes.com/news/southeast-asia-sees-big-shift-e-commerce-during-COVID-19.html

Choudhury, S.R. (2020). *Southeast Asia's online shopping boom is here to stay, even after the pandemic*. 9 June. CNBC. Retrieved from: https://www.cnbc.com/2020/06/09/southeast-asias-online-grocery-shopping-trends-during-coronaviruspandemic.html

Chu, J., Liu, H. and Salvo, A. (2021). Air pollution as a determinant of food delivery and related plastic waste. *Nature Human Behaviour* 5(2), 212-220.

CNA (23 Jul 2021). *Taiwan's COVID-19 curbs drive spike in food packaging waste*. Channel News Asia. Retrieved from: https://www.channelnewsasia.com/news/asia/taiwan-covid-19-food-packaging-plastic-waste-15274022#cxrecs_s

Cordova, M.R., Nurhati, I.S., Riani E., Nurhasanah,and Iswari, M.Y. (2021). Unprecedented plastic-made personal protective equipment (PPE) debris in river outlets into Jakarta Bay during COVID-19 pandemic. *Chemosphere* (268). ISSN 0045-6535.

CPCB. (2020). *Guidelines for Handling, Treatment and Disposal of Waste Generated During Treatment/Diagnosis/Quarantine of COVID-19 Patients.* India: Ministry of Environment, Forest & Climate Change. Retrieved from: https://cpcb.nic.in/uploads/Projects/Bio-Medical-Waste/BMW-GUIDELINES-COVID_1.pdf

d'Ambrières, W. (2019). Plastics recycling worldwide: current overview and desirable changes. *Field Actions Science Reports*, Special Issue 19 | 2019, p.12-21.

Davis, D (2020). *Amazon's Q2 North America revenue surges 43% as web grocery sales triple. 30 July.* Digital Commerce 360. Retrieved from: https://www.digitalcommerce360.com/2020/07/30/amazons-q2-north-america-revenue-surges43-as-web-grocery-sales-triple/

Deloitte. (2021). *The Myanmar Consumer Survey Finding bright spots amidst the uncertainty.* https://www2.deloitte.com/content/dam/Deloitte/sg/Documents/consumer-business/sea-cb-myanmar-consumer-survey-2021.pdf

De-la-Torre, Gabriel Enrique, Dioses-Salinas, Diana Carolina, PizarroOrtega, Carlos Ivan y Santillán, Luis (2021). New plastic formations in the Anthropocene. *Science of The Total Environment*, 754, 14221-6.

Environmental Investigation Agency and Greenpeace. (2019). *Checking out on plastics. A survey of UK supermarkets' plastic habits*. https://eia-international.org/wp-content/uploads/Checking-out-on-plastics.pdf

ERIC (2021). *Save the Earth, Reduce Plastic Waste in the Time of the Online-food Ordering Frenzy — the Environmental Research Institute, Chulalongkorn University (ERIC) Recommends How*. The Environmental Research Institute, Chulalongkorn University. Retrieved from: https://www.chula.ac.th/en/highlight/47741/#Must-the-government-mandate-and-enforce-the-measures?

ESDO. (2020). *COVID-19 Pandemic Pushes Single Use Plastic Waste Outbreak: No Management, No Protection: High Health and Environmental Risk Unveil.* Bangladesh: Environment and Social Development Organization.

Everyday Plastic. (2020). *The everyday plastic survey: Lockdown edition*. Retrieved from: https://www.everydayplastic.org/lockdown-1

FAO. (2020). *The impacts of COVID-19 on the forestry sector: How to respond*? Rome. https://doi.org/10.4060/ca8844en

Feber, D., Nordigården, D. and Varanasi, S. (2020). *No ordinary disruption: Winning with new models in packaging 2030*. McKinsey & Company.

Filho, WL., Voronova, V., Kloga, M., et al. (2021). COVID-19 and waste production in households: A trend analysis. *Science of the Total Environment* 777 (2021) 145997.

GA Circular and Circulate Capital. (2020). *Safeguarding the plastic recycling value chain: Insight from COVID-19 impact in South and Southeast Asia*. GA Circular.

Galgani F., Deudero, S., Foss, MC., and Ghiglione, JF. (2014). *Marine litter in the Mediterranean and Black Seas*. CIESM Workshop Monographs. 18-21 June 2014. Tirana (Albania).

Gardener, C. (16 April 2020). *Nature's comeback? No, the coronavirus pandemic threatens the world's wildlife*. The Conservation. Retrieved from: https://theconversation.com/natures-comeback-no-the-coronavirus-pandemic-threatens-the-worlds-wildlife-136209

Geyer R, Jambeck JR, Law KL. (2017). Production, use, and fate of all plastics ever made. *Sci Adv. 2017;3(7):* e1700782

Geyer R. (2020a) *Chapter 2 - Production, use, and fate of synthetic polymers*. In: Letcher TM, editor. Plastic Waste and Recycling. Oxford: Academic Press; 2020:13–32.

Geyer, R. (2020b). *Unpublished data.* **Cited in** Baseline report on plastic waste. In: Tsakonam M. and Rucevska, I. (2020), Basel Convention Plastic Waste Partnership working group - First meeting. https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/554/original/UNEP-CHW-PWPWG.1-INF-4.English.pdf?1594295332

Goodman Fielder. (March 18, 2021). *The future of good delivery services in Australia for the changing hospitality landscape*. Retrieved from https://www.gffoodservice.com.au/idea/future-of-food-delivery-australia/

Google, Temasek and Bain. (2020). *e-Conomy SEA 2020: Resilient and racing ahead*. Google, Temasek and Bain.

Gorman, D. (2020). *How COVID-19 has shaped online grocery trends.* 20 October. Global Web Index (GWI). Retrieved from: https://blog.globalwebindex.com/chart-of-the-week/online-grocery-trends-amid-COVID-19/

Graulich, K., Köhler, A., Löw, C et al. (2021). *Impact of COVID-19 on single-use plastics and the environment in Europe*. Eionet Report - ETC/WMGE 2021/4. European Environment Agency European Topic Centre on Waste and Materials in a Green Economy.

GREAT for Growth (20021). *Covid-19 – PPE demand & supply perspectives.* Retrieved from: https://www.ifc.org/wps/wcm/connect/1d32e536-76cc-4023-9430-1333d6b92cc6/210402_FCDO_GlobalPPE_Final+report_v14updated_gja.pdf?MOD=AJPERES&CVID=nyiUnTU

Green Health Care Waste. (2020). *Decision Tree for the treatment of COVID-19 waste. Gef, UNDP, WHO and HCWH.* Retrieved from: https://greenhealthcarewaste.org/wp-content/uploads/2020/12/Decision-Tree-for-the-treatment-of-COVID-19-Healthcare-Waste.pdf

Hale, R. C., & Song, B. (2020). Single-Use Plastics and COVID-19: Scientific Evidence and Environmental Regulations. *Environmental Science & Technology*, 54(12), 7034–7036.

Hawkins, G. (2018). The skin of commerce: Governing through plastic food packaging. *Journal of Cultural Economy* 11(5), 386-403.

Heinrich Böll Stiftung. (2019). *Plastic atlas 2019: Facts and figures about the World of synthetic polymers*. ISBN: 3869282118, 9783869282114

Ho, M. (9 June 2021). *ASEAN E-commerce: Beyond the Pandemic*. Retrieved from: https://research.hktdc.com/en/article/NzY4MzkzMzg1

Ho, S. (2020). *Oil industry is waging price war against recycled plastics amid pandemic demand boom.* 13 October. Green Queen. Retrieved from: https://www.greenqueen.com.hk/oil-industry-is-waging-price-war-against-recycledplastics-amidst-pandemic-demand-boom/

Humble, J. (22 May 2021). *Planet or plastic: Can the hospitality industry shrink a 150-million-ton plastics footprint? Smiley* Pete Publishing. Retrieved from: https://smileypete.com/business/hospitality-industry-reduce-plastic-use/

IATA (2014). *Aircraft Cabin Waste Project Report. International Air Transport Association*. Retrieved from: https://www.iata.org/cabin-waste/#tab-2

ICAO. (2021). *Take-off: Guidance for Air Travel through the COVID-19 Public Health Crisis*. Third Edition. 10 Mar 2021.

IFC (2020). *COVID-19's Impact on the Waste Sector*. International Finance Corporation.

IFIC (2020). *COVID-19: May 2020. A second look at COVID-19's impact on food purchasing, eating behaviours, and perceptions of food safety.* International Food Information Council. Retrieved from: https://foodinsight.org/wp-content/uploads/2020/05/IFIC-COVID-19-May-2020.pdf

INTERPOL (2020). *INTERPOL's strategical analysis on emerging criminal trends in the global plastic waste market since January 2018.*

Interreg Europe (2020). *COVID-19: The impact of the pandemic on the waste sector. 2 July*. Interreg Europe News. Retrieved from: https://www.interregeurope.eu/policylearning/news/9076/COVID-19-the-impact-of-the-pandemic-on-the-wastesector/

Islam, F. (2020). *Why a billion items of PPE is not enough. 21 April.* BBC News. Retrieved from: https://www.bbc.com/news/business-52362707

Islam, M.S., Sarkar, T., Khan, S.H., Kamal, A.H.M., Hasan, S.M., Kabir, A., Yeasmin, D., Islam, M.A., Chowdhury, K.I.A., Anwar, K.S., Chughtai, A.A., Seale, H. & Seale, H. (2020). COVID-19 related infodemic and its impact on public health: A global social media analysis. *The American Journal of Tropical Medicine and Hygiene*, 103(4), 1621-1629.

Jang Y.C., Hong S., Lee J., Lee M.J., Shim W.J. (2014). Estimation of lost tourism revenue in Geoje Island from the 2011 marine debris pollution event in South Korea. *Marine Pollution Bulletin* 81 (1): 49-54

Julia, A.M. (2020). *COVID waste: burn it or dump it?* 6 May. Agencia EFE. Retrieved from: https://www.efe.com/efe/english/destacada/covid-waste-burn-it-or-dump/50000261-4239489.

Jun tae, K. (Feb 2, 2021). *(New Focus) Plastic waste crisis thwarts Korea's efforts towards greener future*. The Korea Herald. Retrieved from: http://www.koreaherald.com/view.php?ud=20210202000765

Kavilanz, P (2020). *Used masks and gloves are showing up on beaches and in oceans.* 28 October. CNN Business. Retrieved from: https://edition.cnn.com/2020/10/28/business/ppe-ocean-waste/index.html

Kaza, S., Yao, L., Bhada-Tata, P., and van Woerden, F. (2018). *What a waste 2.0. Global snapshot of solid waste management to 2050*. International Bank for Reconstruction and Development/The World Bank

Kearney (2020). *Consumer support still strong as Earth Day celebrates its 50th birthday*. Retrieved from: https://www.aquapakpolymers.com/applications/

Kelly, O. (2020). *Illegal dumping in Dublin rises 25% during COVID-19 pandemic.* 7 May. The Irish Times. Retrieved from: https://www.irishtimes.com/news/environment/illegal-dumping-in-dublin-rises-25-during-COVID-19-pandemic-1.4246676

Kitz, R., Wlaker, T, Charlebois, S, and Music, J (2021). Food packaging during the COVID-19 pandemic: Consumer perceptions. *International Journal of Consumer Studies.*

Koelmans, A. A., Gouin, T., Thompson, R., Wallace, N. and Arthur, C. (2014). Plastics in the marine environment. *Environmental Toxicology and Chemistry*, 33(1), 5-10.

Kollar, S. (2020). *Adapting our clean swell data collection App for the pandemic. 22 September*. Ocean Conservancy. Retrieved from: https://oceanconservancy.org/blog/2020/09/22/adapting-clean-swell-data-collection-app-pandemic

Kranjec, J. (2021). *Online food delivery market to hit $151.5B in revenue and 1.6B users in 2021, a 10% jump in a year*. 5 January. StockApps. Retrieved from: https://stockapps.com/blog/2021/01/05/online-food-delivery-market-to-hit-151-5bin-revenue-and-1-6bn-users-in-2021-a-10-jump-in-a-year/

Krungsri Research. (2021). *Thailand Industry Outlook 2021-2023: Plastics*. Jan 2021. Retrieved from: https://www.krungsri.com/getmedia/e0db7960-9663-4498-a4a7-d648d892105d/IO_Plastics_210112_EN_EX.pdf.aspx

Ksenia, J.G., Thomas, B., Bethanie, C.A., et al. (2019). Overview of known plastic packaging-associated chemicals and their hazards. *Sci. Total Environ.* 651, 3253–3268.

Kumar, H., Azad, A., Gupta, A., Sharma, J., Bherwani, H., Labhsetwar, N.K. and Kumar, R. (2020). COVID-19 Creating another problem? Sustainable solution for PPE disposal through LCA approach. *Environment, Development and Sustainability*, 1-15.

Kumar, S. (5 June 2021). *World Environment Day: India produced 45,308 tonnes of Covid-19 biomedical waste in previous one year.* Hindustan Times. Retrieved from: https://www.hindustantimes.com/india-news/world-environment-day-india-produced-45-308-tonnes-of-covid-19-biomedical-waste-in-previous-one-year-101622862552910.html

Lakshmanan, R., and Nayyar, M. (25 May 2020). *Personal Protective Equipment in India: An INR 7,000 Cr industry in the making*. Strategic Investment Research Unit (SIRU). Retrieved from: https://www.investindia.gov.in/siru/personal-protective-equipment-india-INR-7000-cr-industry-in-the-making

Lay, B. (2020). *People in S'pore generated 1.33 million kg extra plastic waste during circuit breaker, survey estimates*. 5 June. Mothership. Retrieved from: https://mothership.sg/2020/06/plastic-waste-circuit-breaker

Lebreton, L. & Andrady, A. (2019). Future scenarios of global plastic waste generation and disposal. *Palgrave Commun.* 1–11 (2019). doi:10.1057/s41599-018-0212-7

Lebreton, L. C., Van der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature Communications,* 8, 15611.

Liu, G., Agostinho, F., Duan, H., Song, G., Wang, X., Giannetti, B.F., Santagata, R., Casazza, M. and Lega, M. (2020). Environmental impacts characterization of packaging waste generated by urban food delivery services. A big-data analysis in Jing-Jin-Ji region (China). *Waste Management* 117, 157-169.

Loew, C. (2020, September 11). *Home food delivery services expanding in Japan*. Seafood Source. Retrieved from: https://www.seafoodsource.com/news/supply-trade/home-food-delivery-services-expanding-in-japan

Luat, Q. & Hai, N. (2020, July 26). *Medical masks increase in price, there are signs of shortage*. Nguoi Lao Dong. Retrieved from: https://nld.com.vn/kinh-te/khau-trang-y-te-tang-gia-co-dau-hieu-khan-hang-20200726185229671.htm (*in Vietnamese*)

MPMA (2021). *Annual Report 2020*. Malaysian Plastic Manufacturing Association. https://mpma.org.my/v4/wp-content/uploads/2020/09/MPMA-AR2020-FINAL-30092020.pdf

McIlgorm, A., Campbell H. F. and Rule M. J. (2009). *Understanding the economic benefits and costs of controlling marine debris in the APEC region (MRC 02/2007).* A report to the Asia-Pacific Economic Cooperation Marine Resource Conservation Working Group by the National Marine Science Centre (University of New England and Southern Cross University), Coffs Harbour, NSW, Australia, December.

MEE. (2020). *Management and technical guidelines for emergency disposal of medical wastes induces by the novel coronavirus pneumonia epidemic (in Chinese).* China: Ministry of Ecology and Environment. Retrieved from: http://www.gov.cn/xinwen/2020-01/29/content_5472997.htm.

Meijer, J.J.L, van Emmerik, T., van der Ent, R., Schmidt, C., Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. *Science Advances.* 2021; 7: eaaz5803

MHP. (2020). *Health Care Waste Management in the context of COVID-19 Emergency (Interim Guidance).* Nepal: Ministry of Health and Population. Retrieved from: https://dwssm.gov.np/wp-ontent/uploads/2020/07/HCWM_COVID-19-Guidelines_En.pdf

Morales-Caselles, C., Viejo, J., Martí, E et al. (2021). An inshore-offshore sorting system revealed from global classification of ocean litter. *Nature Sustainability* | VOL 4 | June 2021 | 484–493 |.

Morgan, S. and McBeth, T. (2020). *COVID-19 Impact Report: The impact of COVID-19 across the plastic supply and recycling sectors*. RECycling of Used Plastics Limited (RECOUP). Retrieved from: https://www.recoup.org/download/760/recoupCOVID-19-impact-report

Moynihan, Q.; Walków, M. (3 Aug 2019). *Here's how airlines are fighting against the 6.7 million tons of cabin waste passengers produce every year. Business Insider Polska*. Retrieved from: https://www.insider.com/airlines-battle-cabin-trashflights-plastic-alternatives-2019-8

Mu-Hyun. C. (2020). *Korea sees steep rise in online shopping during COVID-19 pandemic*. 30 March. ZDNet. Retrieved from: https://www.zdnet.com/article/korea-sees-steep-rise-in-online-shopping-during-COVID-19-pandemic/

National Geographic (2020). *Sea to Source: Ganges Expedition. Summary report*. Retrieved from: https://jambeck.engr.uga.edu/wp-content/uploads/2021/02/Sea-to-Source-Summary-Report.pdf

New Straits Times (14 May 2020). *How Alibaba's Lazada Turned Produce Dumped in Virus Crisis into a Business*. (Business). Retrieved from: https://www.nst.com.my/business/2020/05/592499/how-alibabas-lazada-turned-produce-dumped-virus-crisis-business

Nguyen, L. (2020, April 13). *[Graphic] The Ministry of Health guides how to choose and use masks to prevent COVID-19*. Suc Khoe & Doi Song. Retrieved from: https://suckhoedoisong.vn/bo-y-te-chi-cach-lua-chon-va-su-dung-khau-trang-trong-phong-chong-dich-covid-19-n172221.html (in Vietnamese)

NielsenIQ. (2020). *How has COVID-19 impacted Vietnamese consumers?".* 20 February 2020. Retrieved from: https://nielseniq.com/global/vi/insights/analysis/2020/how-has-covid-19-impacted-vietnamese-consumers/

NSW EPA. (2020). *Store waste responsibly during COVID-19.* 14 May. New South Wales, Australia: Environment Protection Agency. Retrieved from: https://www.epa.nsw.gov.au/news/news/2020/store-waste-responsibly-during-COVID-19

NUS. (2020). *The poison of disposables.* 16 July. National University of Singapore Survey. Retrieved from: https://blog.nus.edu.sg/poisonofconsumerism/2020/07/16/the-poison-of-disposables/

Ocean Conservancy (2021). *The pandemic pollution. The rising tide of plastic PPE.* Retrieved from: https://oceanconservancy.org/wp-content/uploads/2021/03/FINAL-Ocean-Conservancy-PPE-Report-March-2021.pdf

Ocean Conservancy. (2020). *International Coastal Cleanup 2020 Report*. Retrieved from: https://oceanconservancy.org/wpcontent/uploads/2020/10/FINAL_2020ICC_Report.pdf

OECD. (2020). *E-commerce in the time of COVID-19. OECD Tackling Coronavirus (COVID-19): Contributing to a Global Effort*. Retrieved from: https://www.oecd.org/coronavirus/policy-responses/e-commerce-in-the-time-of-covid-19-3a2b78e8/

Parashar, N. and Hait, S. (2020). Plastics in the time of COVID-19 pandemic: Protector or polluter? *Science of The Total Environment*, 144274.

Pitcheta, R. (20 Jan 2020). *Malaysia has sent back tons of plastic waste to rich countries, saying it won't be their 'garbage dump'*. CNN. Retrieved from: https://edition.cnn.com/2020/01/20/asia/malaysia-plastic-waste-return-scli-intl/index.html#:~:text=(CNN)%20Malaysia%20has%20sent%20back,garbage%20dump%22%20of%20the%20world

PlasticOceans (2020). *The facts "more than 8 million tons of plastic are dumped in our oceans every year"*. Plastic Oceans International. https://plasticoceans.org/the-facts/

PlasticsEurope (2019). *Plastics – the Facts 2019. An analysis of European plastics production, demand and waste data*. Retrieved from: https://www.plasticseurope.org/application/files/9715/7129/9584/FINAL_web_version_Plastics_the_facts2019_14102019.pdf

Prata, JC., Silva, L.P. Ana, Walker, TR., et al. (2020). COVID-19 Pandemic Repercussions on the Use and Management of Plastics. *Environmental Science & Technology* 2020 54 (13), 7760-7765 DOI: 10.1021/acs.est.0c02178

Promchertoo, P. (2020). *Food delivery services add tonnes of plastic to Thailand's landfills during COVID-19 crisis*. 12 May. Channel News Asia. Retrieved from: https://www.channelnewsasia.com/news/asia/food-delivery-increases-thailandplastic-waste-during-COVID-19-12711692?cid

Ragazzi, M., Rada, E.C. and Schiavon, M. (2020). Municipal solid waste management during the SARS-COV-2 outbreak and lockdown ease: Lessons from Italy. *Science of the Total Environment* 745, 141159.

Rakuten Insight (2021). *Next Normal to Future Normal for Consumers in Asia & US*. Retrieved from: https://insight.rakuten.com/report-next-normal-to-future-normal/

Rawat, S. (30 Apr 2021). *9.1 million thronged Mahakumbh despite Covid-19 surge: Govt data*. Hindustan Times. Retrieved from: https://www.hindustantimes.com/cities/dehradun-news/91-million-thronged-mahakumbh-despite-covid-19-surge-govt-data-101619729096750.html

ResearchAndMarkets.com (2021). *Flexible Plastic Packaging Market by Type (Pouches, Rollstocks, Bags, Wraps), Material (Plastic & Aluminum Foil), Application (Food, Beverage, Pharma & Healthcare, Personal care & Cosmetics), Technology, and Region - Global Forecast to 2025*. Retrieved from: https://www.marketsandmarkets.com/Market-Reports/flexible-packaging-market-1271.html

Ritchie, H. (1 May 2021). *Where does the plastic in our oceans come from?* Our World in Data. Retrieved from: https://ourworldindata.org/ocean-plastics

Robin, R. S., R. Purvaja, D. Ganguly, G. Hariharan, A. Paneerselvam, R. T. Sundari, R. Karthik, C.S. Neethu , C. Saravanakumar , P. Semanti , M.H.K. Prasad , M. Mugilarasan , S. Rohan , K. Arumugam , V.D. Samuel , R. Ramesh. (2021). COVID-19 restrictions and their influences on ambient air, surface water and plastic waste in a coastal megacity, Chennai, India. *Marine Pollution Bulletin*. 171: 112739.

Rowan, N.J., and Laffey, J.G. (2020). Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic–Implications for efficacy, re-use and sustainable waste management. *Science of the Total Environment*.

Saliua, F., Veronellib, M., Ragusoa, C. et al. (2021). The release process of microfibers: from surgical face masks into the marine environment. *Environmental Advances* Volume 4. Pp.

Sarah, C. (November 22, 2020). *Post-Covid-19 New Normal] Korea not winning war on plastic yet despite best efforts*. Korea JoongAng Daily. Retrieved from: https://koreajoongangdaily.joins.com/2020/11/22/business/indepth/plastics-plastic-wastes-ice-packs/20201122183100531.html

Schmidt, C., Krauth, T., and Wagner, S. (2017). Export of Plastic Debris by Rivers into the Sea. *Environ. Sci. Technol.* 2017, 51, 21, 12246–12253.

SEC. (2018). *Consumer plastic and plastic resource ecosystem in Singapore*. Singapore Environment Council. Retrieved from: https://sec.org.sg/seaa/wp-content/uploads/2018/09/SEC-Plastic-Resource-Study-Paper_Final1.pdf

Simachaya, W. (2020). *Solid waste during COVID-19.* 30 April. Thailand Environment Institute. Retrieved from: http://www.tei.or.th/en/blog_detail.php?blog_id=49

South China Morning Post. (August 7, 2020). *Hong Kong third wave: Surge in plastic waste calls for green unity*. Retrieved from: https://www.scmp.com/comment/letters/article/3096163/hong-kong-third-wave-surge-plastic-waste-calls-green-unity

Specialty Food Magazine (28 May 2021). *We need to rethink packaging for food to go.* Retrieved from: https://www.specialityfoodmagazine.com/news/sustainable-packaging-for-food-to-go

Statista. (2021). *Main reasons for increasing orders through food delivery apps during the COVID-19 pandemic in the Philippines as of June 2020, by age group*. Retrieved from: https://www.statista.com/statistics/1147577/philippines-reasons-for-increasing-orders-from-food-delivery-apps-during-covid-19-by-age/

Staub, C. (2020). Budget shortfalls threaten local recycling programs. 27 May. *Resource Recycling.* Retrieved from: https://resource-recycling.com/recycling/2020/05/27/budget-shortfalls-threaten-local-recycling-programs/

Talking Economics. (4 May 2020). *Coping with COVID-19: Economics of Social Media Based Business in Sri Lanka during Crises*. Retrieved from: https://www.ips.lk/talkingeconomics/2020/05/04/coping-with-covid-19-economics-of-social-media-based-business-in-sri-lanka-during-crises/

Tam, F and Huang, Z. (2020). *Food delivery giant Meituan's sales beat estimates*. 21 August. Bloomberg. Retrieved from: https://www.bloomberg.com/news/articles/2020-08-21/food-delivery-giant-meituan-sees-recovery-in-sales-beat

Tanakasempipat, P. (2020). *Plastic piles up in Thailand as pandemic efforts sideline pollution fight*. 11 May. Reuters. Retrieved from: https://www.reuters.com/article/us-health-coronavirus-thailand-plastic/plastic-piles-up-in-thailand-aspandemic-efforts-sideline-pollution-fight-idUSKBN22N12W

Tandon,S., and Bhalla, T. (5 June 2020). *Zomato sales back grocery as food delivery recovers*. Mint. Retrieved from: https://www.livemint.com/companies/start-ups/zomato-re-focuses-on-food-delivery-as-orders-improve-11591362119072.html

The Benioff Ocean Initiative. (2019). *River Plastic Pollution: Considerations for addressing the leading source of marine debris*. Retrieved from: https://www.boi.ucsb.edu/wp-content/uploads/2019/05/River_Plastic_Pollution_BOI_white_paper.pdf

The Laotian Times (16 Aug 2021). *Foodpanda launches pandamart virtually.* https://laotiantimes.com/2021/08/16/foodpanda-launches-pandamart-virtually/ [Accessed on 28 August 2021]

The PEW Charitable Trust and SystemIQ. (2020). *Breaking the plastic wave. A comprehensive assessment of pathways towards stopping ocean plastic pollution*. https://www.pewtrusts.org/-/media/assets/2020/10/breakingtheplasticwave_mainreport.pdf

Thong, V. (14 May 2020). *Has Covid-19 subverted the traditional Vietnamese consumer?* VN Express. https://e.vnexpress.net/news/business/industries/has-covid-19-subverted-the-traditional-vietnamese-consumer-4098697.html

Thung, T and Saad, S.N.C (20 September 2020). *The impacts of Movement Control Order (MCO) towards waste generation in Penang Island: Public Survey.* Penang Green Council. Retrieved from: https://www.pgc.com.my/2020/wp-content/uploads/2020/10/The-Impacts-of-Movement-Control-MCO-Towards-Waste-Generation-in-Penang-Island.pdf

Tri, N. (2021, April 28). *Face masks are piled up, their prices are continuously reduced, but no one buys, why?* Tuoi Tre Online. Retrieved from: https://tuoitre.vn/khau-trang-chat-dong-ha-gia-lien-tuc-nhung-ban-khong-ai-mua-vi-sao-20210428082941 51.htm (in Vietnamese)

UNCTAD (2020). *Global trade in plastics: insights from the first life-cycle trade database*. UNCTAD Research Paper No. 53 UNCTAD/SER.RP/2020/12. United Nations Conference on Trade and Environment. Retrieved from: https://unctad.org/system/files/official-document/ser-rp-2020d12_en.pdf
UNCTAD (22 June 2020). *Cambodia's digital startups help blunt economic impact of COVID-19*. Retrieved from: https://unctad.org/news/cambodias-digital-startups-help-blunt-economic-impact-covid-19

UNDP, Lao PDR (2021). *#GOECO-friendly food packaging (part 1).* Retrieved from: https://www.la.undp.org/content/lao_pdr/en/home/blog/2021/-goeco-friendly-food-packaging-.html

UNEP & WRI (2018). *Legal limits on single-use plastics and microplastics: A global review of national laws and regulations*. Retrieved from: https://www.unep.org/resources/report/legal-limits-single-use-plastics-and-microplastics

UNEP and WTTC (2021). (2021). *Rethinking single-use plastic products in travel & tourism - Impacts, management practices and recommendations*. United Nations Environment Programme and World Travel & Tourism Council. Nairobi.

UNEP. (2020). *COVID-19 Waste management Factsheets*. Geneva: United Nations Environment Programme. Retrieved from: https://www.unep.org/resources/

UNEP (2021). *Addressing Single-use Plastic Products Pollution Using a Life Cycle Approach*. Nairobi: United Nations Environment Programme.

UN-Habitat. (2020). *Strategy guidance: Solid waste management response to COVID-19.* Geneva: UN-Habitat. Retrieved from: https://unhabitat.org/sites/default/files/2020/05/unhabitat_strategy_guidance_swm_reponse_to_covid19.pdf

United Nations Environment Programme (2018). *Single-Use Plastics: A Roadmap for Sustainability*. Retrieved from: https://www.euractiv.com/wp-content/uploads/sites/2/2018/06/WED-REPORT-SINGLE-USE-PLASTICS.pdf.

UNWTO (2021). International Tourism and COVID-19. *Tourism Data Dashboard.* Retrieved from: https://www.unwto.org/unwto-tourism-dashboard

van Fan, Y., Jiang, P., Hemzal, M. and Klemeš, J.J. (2021). An update of COVID-19 influence on waste management. *Science of the Total Environment* 754, 142014.

Wang, A. N., Ma, X. C. and Zhang, C. (2017). *20 million takeaway orders per day lead to huge takeaway packaging waste (in Chinese).* 21 September. Xinhuanet. Retrieved from: http://www.xinhuanet.com/mrdx/2017-09/21/c_136626055.html

Watukara, A. (2020). Reshaping E-Commerce in Sri Lanka: Prospects Post COVID-19. Retrieved from: https://www.linkedin.com/pulse/reshaping-e-commerce-sri-lanka-prospects-post-ajith-watukara-/

WEF. (2016). *The new plastics economy: Rethinking the future of plastic*s. World Economic Forum.

WHO. (2020). *Water, sanitation, hygiene, and waste management for SARS-CoV-2, the virus that causes COVID-19: Interim guidance*. WHO. Retrieved from: https://apps.who.int/iris/rest/bitstreams/1292822/retrieve

WHO. (3 Mar 2020). *Shortage of personal protective equipment endangering health workers worldwide*. World Health Organization. News Release. 3 March. Retrieved from: https://www.who.int/news-room/detail/03-03-2020-shortage-of-personal-protectiveequipment-endangering-health-workers-worldwide

Williams,D.L., Gerba, C.P., Maxwell, S., and Sinclair R.G. (2011). Assessment of the potential for cross-contamination of food products by reusable shopping bags. *Food Protection Trends*, Vol. 31, No. 8, Pages 508–513

Wipatayotin, A. (2020). *Anti-plastic campaign starts to hit home.* 1 January. Bangkok Post. Retrieved from: https://www.bangkokpost.com/thailand/general/1826649/anti-plastic-campaign-starts-to-hit-home

Woodward, J., Li, J., Rothwell, J. et al. Acute riverine microplastic contamination due to avoidable releases of untreated wastewater. *Nat Sustain* (2021).

Wu, W. (27 May 2021). *Environmentalists warn face masks causing plastic pollution*. Taiwan News. Retrieved from: https://www.taiwannews.com.tw/en/news/4210802

Yeo, A. (02 August 2021). *Annual plastic usage is getting worse - 148,000 tonnes for food packaging alone*. Bernama. Retrieved from: https://www.bernama.com/en/thoughts/news.php?id=1988370

Zainal, F., Trisha, N., and Kaur, M (10 August 2020). *Expert: Over 10 million face masks binned daily.* TheStar. Retrieved from: https://www.thestar.com.my/news/nation/2020/08/10/expert-over-10-million-face-masks-binned-daily

Zengkun, F. (8 Nov 2019). *Going plastic-free: How hotels are joining the anti-plastic fight*. Eco-Business. Retrieved from: https://www.eco-business.com/news/going-plastic-free-how-hotels-are-joining-the-anti-plastic-fight/

Zhang, Z. (2021). *How COVID-19 will transform the fresh food industry in China.* Retrieved from: https://www.china-briefing.com/news/how-Covid-19-will-transform-china-fresh-food-industry-investment-opportunities/

ABOUT THE TECHNICAL PAPER

The Technical Paper "Use of disposable plastics and COVID-19 in Asia and the Pacific: Impact on plastic pollution in waterways and rivers" aims to contribute and complement the advances in plastics management during the COVID-19 pandemic by compiling information on COVID-19 and single-use plastic products pollution through an extensive review of the literature (both peer-reviewed scientific research and non-peer-reviewed sources) available in the public domain.

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