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Sustainable textile industry: Balancing growth and environmental concerns in Bangladesh

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Abstract

Over the last three decades, the textile and apparel (T&A) sector has been the primary engine of economic growth in Bangladesh. The (T&A) industry's widening contribution led the country to sustained economic growth, reduced poverty and increase in per capita income. Thanks to its competitive edge a large pool of cheap labor, easy access to power, and a huge job creation potential the (T&A) sector has become the most thriving industry in Bangladesh to date. But the pursuit of rapid economic growth has resulted in the explosion and hasty construction of textile factories and enterprises. The growing textile enterprises, most of which are concentrated in a few places, is taking a heavy toll on the nation's human health. ecosystems, that the environment as a whole. Thus, it is essential to approach the burgeoning threat of environmental deterioration, in a sustainable manner, which achieves a balance between (T&A) industrial development and inflicts the least possible trauma on the environment and human health. That's because the nation's biggest money-maker and job-creator has become one of its biggest polluters. This paper will analyze the root causes behind Bangladesh's poorly managed T and A sector and its negative impacts on environment and human health and will mention some possible solutions to improve the environmental performance of this sector and ensure its safe development.

Keywords: (T&A) Industries; Economic Growth; Environment; Textile Factories

1. Introduction

Despite its longstanding history of textile production dating back to British period with the famous "Muslin," the industry closed down to a large extent during Pakistani era as due to poor maintenance and lack of institutional support. But Bangladesh has prioritized rapid economic growth, eliminating extreme poverty and widespread industrialization since the mid-1970s. This why the first industrial policy come into being in 1973 aimed at moving from agriculture to industry. Despite the establishment of the first textile company "Desh Garment" in 1979 but initially, the Bangladeshi government did not see the potential until textile and apparel (T&A) sector gave a positive sign in 1982. To revive the waning textile industry, the state has begun to provide incentives such as duty-free importation of capital machinery, loans, and bonded warehouse services (Mishu, 2018; Quddus and Rashid, 1999; Siddiqi, 2005). By 1990 Bangladesh's (T&A) sector was a productive one. The number of textile companies grew from 47 in 1982 to 2,900 in 1999, and Bangladesh became the sixth-largest supplier of textile products to the US market (Banglapedia, 2015).

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Figure 1 depicts the increasing economic contribution of the textile industry for Bangladesh between 1995 and 2020. As shown in Figure 1, (T&A) is a factor that is continually and significantly influencing the economic development of Bangladesh. In 1995, (T&A) made up 53.0% of overall export revenue, growing to an astonishing 89.0% in 2020, and indeed this trend is persistently accelerating. This industry has over 7,000 factories and currently exports $29.21 billion which is 6.4% of the global export total (DATABD. CO, 2020). Proton and Peroqua have grown exponentially due to low gas and power prices, low-wage labor, especially of previously-unemployed women, and beneficial government rules (Mottaleb and Sonobe, 2011).

Fast industrialization, on the other hand, occurred in a few cities such as Dhaka without proper planning (Begum et al., 2011). Even while the Bangladeshi government sought to implement policies that laid a strong manufacturing base for the economy, environmental concerns were swept under the rug. Because of the low cost of labor and energy, this most profitable industry (T&A) gained a big advantage, which caused it to concentrate in big cities. The proportion of factories is particularly high in Dhaka and the neighboring cities, where 75.0% of the 7,000 (T&A) factories are located (Rana, 2016). (T&A) businesses are having immensely unpleasant and unplanned adverse impacts on the ecology and human health of Bangladesh. For example, 60.0% of pollution are due to industrial activity, in Bangladesh, textile sector is the second most polluting sector after the tannery sector (Greer et al., 2010). There are 719 washing, finishing and dyeing industries located in Dhaka and adjacent region where more than 200-ton wastewater is generated per day which cripple the lives of 18 million people (PACT, 2016; World Bank, 2007).

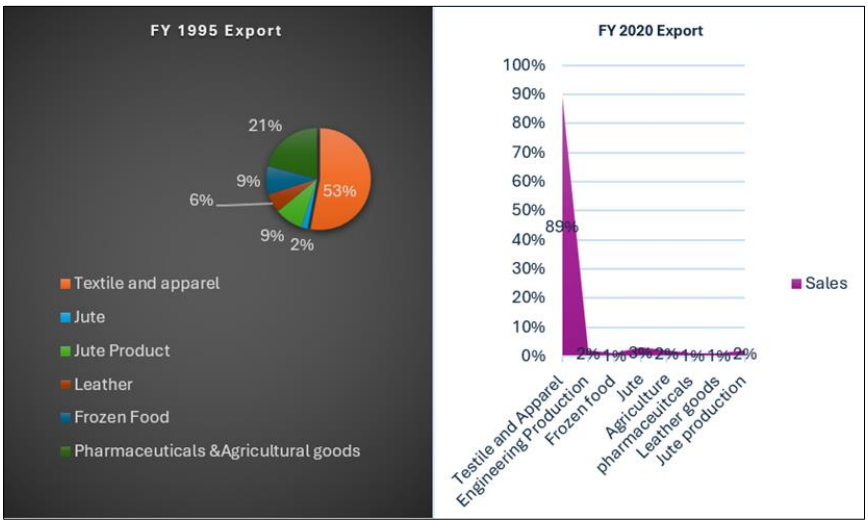

Figure 1 Contribution of the textile and apparel sector

The impact of textile dyes on waterbodies adjacent to (T&A) factories is known to be substantial (Wang et al., 2022). The Turag, Bangshi, Shitalakkhya, and Balu rivers faces the lack of dissolved oxygen severely (Rashid, 2012; Singh, 2019). In addition, Dhaka, the capital of Bangladesh, has the third most polluted air in the world, and one of the major sources of this problem is the poorly run textile and clothing industries (Air Quality Index [AQI], 2019). Due to the adverse impact, the government has classified (T&A) as a "red industry" in line with the There is ample research on engineering issues (e.g. wastewater management, and the production process), but little research exists on policy issues from the institutional and stakeholders' perspective. This will help to ensure improved guidance for integrating environmental issues into (T&A) industrial processes (Sakamoto et al., 2019). Hence, to realize the socioeconomic benefits of (T&A) business and also ensure environmental preservation, immediate reform in the existing industrial policy is imperative. Bangladesh Environment Conservation Act (1995) and Environment Conservation Rules (1997).

2. Literature review

2.1. Bangladesh – The Textile and Apparel Industry and Its Socio-economic Effect

Industrialization has been seen as the overarching principle and best strategy for fast economic growth for most countries. Kaldor (1967) also identifies industrialization as the primary engine of growth and recognizes the strong possibility for industrialization to transform stagnant economies to mature economies. Nevertheless, the pattern of comparative advantages dictates the structure of industries for any specific country (Balassa, 1979). Like in the recent past, a large reservoir of cheap labor was a factor of comparative advantage of Bangladesh in late 80s, which led this

country to patronize (T&A) industry as its best option in such a scenario. The (T&A) Industry has been profitable for Bangladesh for the past two decades and a half or so with steady GDP growth rate of the country with constant foreign exchange earnings (Lu, 2019). From a macro perspective, (T&A) can be considered to be fulfilling two critical functions in the Bangladesh economy. First, through entering direct foreign export revenue. Two, by creating job opportunities around the nation. Bangladesh Economic Review (2019), reported that (T&A) sector contributes over 80.0% to the nation's total export. During the year 2018-2019, it earned a total of $27,563 million, which was nearly 83.9% of the total national export. The (T&A) industry comprises about 17.0% of total GDP of Bangladesh, which is the highest rate of contribution from any industry to GDP of national income (MacLean and Olderman, 2014). Bangladeshi (T&A) export increases over 60.0% (Research and Market,2018;4 (1)) between 2012-2018. com, 2019). Over the past seven years, Bangladesh has maintained an annual growth rate faster than 7.0% due to the strong and consistent contribution of (T&A) sector (Macrotrends, 2020). Recognizing this progressive expansion of this domain, the nation had set an arduous export objective of greater than $50 billion for the 2022-2023 financial year (Ishaque, 2019).

In the aspect of employment generation (T&A) is the most fruitful and flourishing sector according to the country has 7,000+ factories which absorbed 5million people as employees where the women are 80.0% (Bangladesh Economic Review, 2019). The need for educating and providing employment opportunities for women has always been one of the gigantic challenges for Bangladesh. Though an increasingly open invitation at the hands of the (T&A) factories, that employment would come as most women who sought MTV in the 80s would otherwise find their bodies in the rooms of unpaid sex playhouses or 20 million women married to men for a mere 10% of their income.

2.2. Textile and Apparel Industry Impact on Global Environment and Health

The (T&A) industry takes roots from large negative impacts on the environment (Visvanathan et al., 2000). The wastes and effluents in fact, the effluents generated from (T&A) industry not only contaminate ground water quality but also one of the leading contributors to the water pollution and thus being the most polluting among all industrial sectors (Odjegba and Bamboos, 2012; World Bank, 2019). According to a report from the Ellen MacArthur Foundation (2017), the global carbon emission of textile industries by 2050 will be 26.0%, and microplastic will increase up to 22 million tons per year. Microplastics from the production of polyester in textile factories accounted for 31.0% of ocean pollution of plastic in the world (International Union for Conservation of Nature [IUCN], 2019).

While the (T&A) industry was the main driver for the euphoric double-digit growth of China through the 2000s, this is now leading to extreme environmental degradation, primarily caused the huge number of effluents (Greer et al., 2010; You et al., 2009) released from those factories. As an example, wide use of dichlorodiphenyltrichloroethane (also known as below abbreviation) in Jiangsu has caused serious pollution, making the Yangtze River and Tahu Lake become one of the most polluted water bodies in China (He et al. 2012; Qin et al. 2007). Additionally, nitrogen discharges at high concentrations of spillage have been found to be in the province's Kuihe River (Wu et al., 2007).

The main reason for this is the depletion of oxygen in water, which has a more serious effect and pose great threat to the aquatic ecosystem (Kant, 2012). As the most polluting industry in Indonesia with a biological oxygen demand (BOD) load as high as 3,270 kg/day (Sembiring, 1985), since 1985, the textile industry has become one of the largest industries producing acidic effluent. Today, the textile factory dyes and their uncontrolled discharge to waterbodies are causing chemical Fukushima for Indonesia (Sweeny, 2015) Research from Boucher and Friot (2017) published by the International Union for Conservation of Nature (IUCN) shows that 35.0% percent of all microplastics originate from the textile industry, and furthermore, alarming statistics state that about 85.0% of textiles waste is sent to landfill each year (Mc-Fall Johnsen, 2019).

Textile effluents are causing severe human illness in the world. Almost 40.0% of worldwide used colorant include the organically bound choline called 'carcinogen' and a number of these particles vaporize into the atmosphere, it is very serious respiratory infection for people particularly kids (Masood et al., 2014). India, as one of the three largest producers of textile goods, has at least some states like Tamil Nadu, Uttar Pradesh, Haryana, Gujrat, and Andhra Pradesh (Deshpande 2020) that have been chronicling an acute environmental crisis. According to the Ministry of Environment and Forest of India, the textile industry is one of the most polluting industries (Garg and Kaushik, 2007).

2.3. Negative effects of textile and apparel industry on ecosystem and human health in Bangladesh

Bangladesh is dealing with an increasing problem caused by the concentration of the majority of its (T&A) factories in a small number of the country's large urban areas. According to the Department of Inspection for Factories and Establishments (DIFE, 2019), around 3,000(T&A) factories functioning in Dhaka. Most of the remaining factories are located in Gazipur and Narayanganj, which lie next to Dhaka. Also, these factories of (T&A) are in a few districts; the result of which is becoming of terrible air, water and soil pollution in urban areas, resulting of which is accumulative

effect on environment. For Bangladesh textile sector, about 2,000,000 tons of dyes converted to effluent via dyeing, printing and finishing process (Mia et al., 2019). The untreated effluents that industries release directly or indirectly affect over 200 rivers and most of them are (T&A) factories (Mathews, 2018). According to a study in 2016, the wastewater of (T&A) industry was approximately 217 million m3 in Bangladesh and this volume is expected to reach around 349 million m3 by 2021 assuming that the current operation process remains the same (DIFE, 2019). According to a study by WHO, Bangladesh is one of the countries with the highest level of antibiotic river pollution with 300 times more concentration of metronidazole than the normal limit (Singh, 2019). In addition, aerial fields and plants have also been examined and have been found to contain chemicals typically used to dye in textile plants (Islam et al., 2013). Consumption of foods contaminated with heavy metals has been proved to have serious effects on human health and productivity, and in the longer run on economic development. The rate of illness among residents of Hazaribagh, Savar, Keranigonj, Tongi, Ashulia and similar places, where concentrations of textile and tannery industries exist, is 16.0% higher compared with those of other parts of Bangladesh (Nishat et al., 2001). This dirty water and air contribute to many gastrointestinal and respiratory diseases such as dysentery, diarrhea, skin diseases, food poisoning, asthma and bronchitis (General Economic Division, 2019; Gurley et al., 2013). None of these is fully or comprehensively solution-focused, although there are some partial solutions that attempt to mitigate, reduce or address (T&A) industry pollution [12, 13]. Historically, (T&A) factories have considered planting ETPs as optional even though Bangladesh Environment Conservation Act (1995) would make it mandatory. Corruption, lack of political will, and poor departmental coordination are key determinants for the concentration of (T&A) factories in Dhaka and subsequent environment pollution (Belal et al., 2015). Moreover, Department of Environment (2018) and relevant stake holders seldom shares the requisite data and consequently planning solutions and developing guidelines based on quality data becomes a challenging job (Sakamoto et al., 2019).

3. Methodology

This will be an exploratory research study by means of qualitative research approach and quantitative research approach. The research will rely on secondary data obtained from various sources including relevant journal articles, books, research works on academia, studies carried out by development partners and donors, different Bangladeshi ministries' websites, published reports like those from Bangladesh Bureau of Statistics, Annual Economic Review, Annual Development Program, Seventh Five Year Plan Bangladesh Bank, and the reports of Planning Commission of Bangladesh. In addition to that, reports prepared by the other international organizations, such as Green Peace, UNDP, UNEP, UNFCCC, World Bank and WTO will be used. Reports and updates from both national and international newspapers will be consulted to understand the present state of (T&A) industry in Bangladesh and its contribution to environmental degradation. The data collected would be analyzed, processed and tabulated in order to report the findings in a systematic and unbiased way. The work has been broadly split into three broad sections:

- Trend analysis of industrialization with special emphasis on (T&A) industry and its effect on economy of Bangladesh,
- The following, the environmental and health impact assessment of poorly planned (T&A) industry, and
- Devising recommendations from the findings of this research to harmonies industrialization with environmental conservation in Bangladesh.

4. Results and discussion

4.1. Little Attention to Environmental Protection in Industrial Policies

The Government of aims to accelerate economic development, raise the incomes of the poor and create jobs.

The first industrial policy of Bangladesh was formulated in 1973. Since then, nearly a dozen industrial policies have been announced. However, except the last one formulated in 2016, almost all the industrial policies were driven by the quest of rapid economic growth with little or no concern for the environment.

Broadly speaking, industrial policies of Bangladesh were predominantly growth-oriented with the aim to alleviate poverty and expedite industrial growth. Analyzing first to latest (1980 to 2010) policy some major common trends are appeared: fast economic growth and increasing emphases on privatization, increasing production efficiency, increase in number of export processing zone and manufacturing industry as the prime engine for growth (Ministry of Industries, 2016). Yet, in the pursuit of these economic goals, environmental aspects have often been neglected (Banna, 2014; Roy, 2018).

Bangladesh has also followed the traditional model of industrial policy, which is based on credit concession, loan facilities, government interventions, and privatizations (Schwarzer, 2013). Indeed, Government resorted to stimulation mechanisms to enhance productivity and enlarge industries to ensure maximum returns from labor and capital (Altenburg and Assmann, 2017; Sarkar, 2005). Recants trends of global and local environmental degradation and climate change have raised alarm which motivated the Government of Bangladesh to revise traditional industrial policy in 2016 (Roy, 2018).

4.2. Poor Spatial Distribution of Textile and Apparel Factories

Since there was no specific regulation in place on establishing a textile industry during its early stage, (T&A) factories have concentrated primarily in Dhaka and surrounding districts due to higher access to water supply, labor and energy. It is estimated that there are upwards of 7,000 (T&A) factories in (Labowitz 2016)

Dhaka, Narayanganj, Gazipur and Chattogram, whereas over 90.0% of them are in Bangladesh. There is a process of transferring (T&A) factories from Dhaka to adjacent cities but Dhaka is still unjustifiably overloaded with (T&A) factories. Another study by Khan et al. (2016) identified that around 40.0% of (T&A) factories are located at Mirpur and Uttara areas of Dhaka City. Moreover, in 1993 the number of workers in (T&A) factories was one million, which now surged to four million workers, where more than 80.0% of them reside within the city Dhaka and its nearby metropolitan areas such as Savar, Tongi and Ashulia, etc. (Khan et al., 2016). Apparel industry is also stated as the reason of migration and hence pressure on health and environment in the districts of Dhaka and other cities by world bank (2007) report. In these respective cities, uncontrolled clustering of the (T&A) factories are causing environmental problems in addition to transportation and housing crises (Alam, 2018; Ali et al., 2008; Sultana et al., 2013).

4.3. Retaining Mercury Inadequate Effluent Treatment Plants

According to Environment Conservation Rules (1997), the (T&A) industry classified as waste intensive, i.e. one of the most polluting industries that need ETP (Haque, 2017b; Rupp, 2008). But then, estimated factories in Bangladesh with an ETP are inconsistent and go from 40.0% to 80.0% eighty, and small textile factories generally do not have ETP (Haque, 2017b). Furthermore, only 29.0%of wet processing units are in full accordance with all of the required legislation (Park, 2011). Haque (2017b) took an exploratory approach and gathered 290 records about penalties on water pollution from various Bangladeshi newspapers published between 2011 and 2016. And revealed that 255 of the samples were of (T&A) industry, which indicated that the cost of installing ETPs referring to (T&A) industry is higher than each fine of factory owner. As a result, having a green policy or ETPs turns out to be unprofitable for factory owners in Bangladesh (Karp and Stevenson, 2012).

4.4. Weak Enforcement of Environmental Regulations and Regulatory Issues

Bangladesh has about 200 environmental ordinances and regulations as well as environmental conservation and ecosystem protection clauses (Khan, 2000). But, despite quite low success rate (Reazuddin and Hoque, 2002), in practice, Ministry of Environment (2019) carried out poor standard enforcement (Reazuddin and Hoque, 2002). Owing to this enforcement ineffectiveness, these rules breached routinely owing to bureaucratic and political corruption, and absence of political resolve (Belal and Roberts, 2010; Mohammad, 2011). Despite the availability of several environmental laws to protect water resources from industrial effluents, poor enforcement resulted in no significant impact on reducing pollution (Karn and Harada, 2001). A study by Browne et al. (2014) on enforcement and stringency show how weak the institutions of

Bangladesh, according to which Bangladesh is also doing poorly in the implementation of environmental laws. In terms of enforcement performance, Bangladesh gets the second to last position just above Vietnam, while the performances of the other competitive countries like Malaysia, Thailand, Cambodia, and Indonesia are much better. According to a World Bank (2018) report, it is the lax enforcement of environmental laws, which is a big barrier in mitigating pollution in Bangladesh.[6] For instance, Haque (2020) reveals that it is easiest to breach the environmental regulations in Bangladesh. Moreover, a weak monitoring, accountability, and punitive measures system along with poor quality of Environmental Impact Assessment (EIA) have facilitated the non-compliance of environmental laws (Belal et al., 2015; Haque, 2017a; Miah, 2015).

Table 1 Physiochemical parameters of effluent samples in different districts of Bangladesh

Region/districts	Temp	pH	TDS (mg/l)	COD (mg/l)	BOD (mg/l)	EC (us/cm)	Sources
Dhaka	37.0-65.0	8.7-10.0	460-5,981	508	90-460	250-7,950	Ahmmed and Begum (2010), Kamal et al. (2016), & Mahfuz (2011),
Narayanganj	50.0	6.8-11.0	152-1,011	268-1,275	60-450	592-1,696	Islam et al. (2011) & Sultana et al. (2013)
Gazipur	34.7-48.8	8.9-10.0	531-1,006	-	560-965	0.88-1,701	Hannan et al. (2011) & Sultana et al. (2013)
Chattogram	25.0-55.0	8.9-11.0	685-1,338	487-1,120	140-420	1,108-1,907	Sultana et al. (2013)
Reference: Value	50	6.5-9.0	2,100	200	50	1,200	DoE (2008)

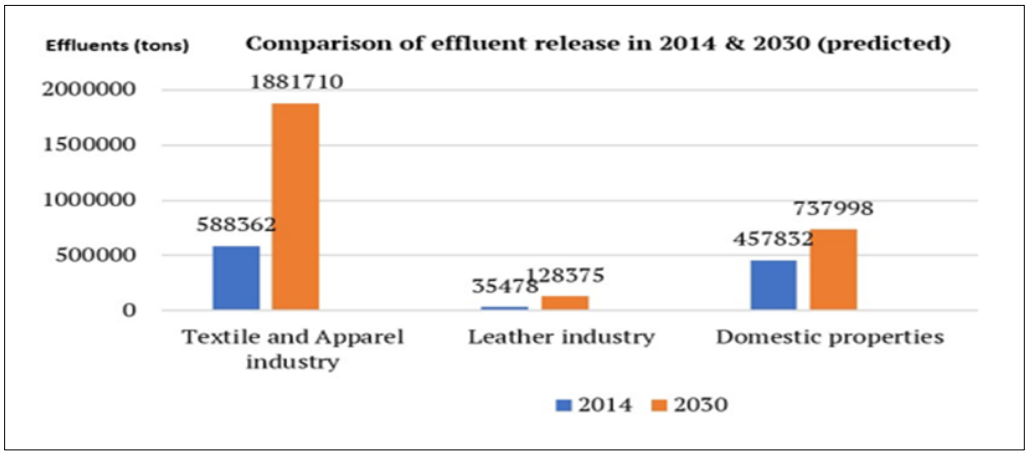

Figure 2 Pollution caused by different sectors

4.5. Important effects on Environment and Natural Ecosystems

The people's report on Bangladesh environment show severe degradation of the fundamental determinants of the environment such as air, water and soil in Bangladesh (Rahman, 2001 and Chowdhury, 2001). This environmental calamity is attributed to the discharge of untreated industrial effluents (Bala and Yusuf, 2003). Akter et al. In recent research carried out by Dastjerdi et al. (2022), it was concluded that the textile factories cannot be transferred to a safer environment due to insufficient political commitment and economic constraints. In Savar, Tongi, and Ashulia surrounding the capital, croplands in huge areas have been destroyed due to toxic wastes from nearby tanneries and dyeing factories (Bhuiyan et al., 2011). A study by Hoque et al. (2018) and filed by Alizadeh et al. (2018), and based on the results obtained for the untreated effluents of these factories) disclose troubling results. The water of these water bodies are unfortunately highly polluted by industrial effluents and this has contributed to the process of gradual extinction of aquatic biodiversity by depleting the minimum amount of oxygen in water necessary for maintaining the aquatic ecosystem (Alom, 2016). The minimum quantity of dissolved oxygen has already been lost on the Turag, Buriganga and Balu rivers for living creatures and as a result the major part of fishes and other aquatic species has vanished (Reza and Yousuf, 2016). Over 90.0% of washing, dyeing, and finishing (WDF) units are located close to rivers and canals in Dhaka, and Narayanganj because of the easier access to water and convenient disposal and discharge (ADSL, 2009; Sultana et al., 2013). As a result, the rivers turned into the epicenter of water pollution in Dhaka and adjacent districts (Haque 2018). A study by Islam et al. (2011) (T&A) factories in Dhaka, Narayanganj, Gazipur and Chattogram have deteriorated the water quality to the point that aquatic species are under threat of extinction. As shown in the table 1 table 1, the level of total suspended solids, turbidity, BOD and chemical oxygen demand level was

alarming as compared to reference values. Responsive despite the rapidly degrading water quality of the Buriganga, Shitalakkhya, and Turag Rivers given their pollution in the areas surrounding (T&A) factories are largely concentrated the situation in detail (Restiani, 2016). The chemical wastewater discharged from textile and dyeing industry is expected to be 349 million m3 in 2021 (Hossain et al., 2018).

4.6. Water and Air Pollution Intensity and Related Economic Loss

Indications of future water pollution crisis in rivers of Dhaka and adjacent districts have been discovered in a comparative study, owing to effluent release. If 'business as usual' were to remain and no preventive measures were pushed in place, as shown in figure 2, the polluting effluents released from textile factories will peak at a dangerous level by 2030. Moreover, industrial wastes showed adverse effects on standards of living and other social aspects of highly industrialized regions. The textile effluents affected soil quality negatively, resulting in soil erosion, and the increase of organic and inorganic particulate matters, which is directly linked to health hazards. Again from Table 2, we observe that the number of very unhealthy and extremely unhealthy air quality days has been on the rise in both Dhaka and the adjacent districts. A study by Mia et al. (2019) reported that during the textile industry processing of the dye, 10.0% to 25.0% of the dye is lost, which is one of the major contributors for air pollution in the northern zone of Dhaka. Broadly, air pollutants are gasses (CO2, SO2, NO2) (Vallero,2014). Sakamoto et al. The study is conducted by Sonali Bansal et al. (2019), which shows that due to their high thermal and photostability, the chemical dyes used in (T&A) factories remain in the environment for a long time which cause several respiratory and skin diseases. According to a World Bank (2006) report on `Bangladesh country environmental analysis'+, environmental pollution causes 22.0% of the diseases – predominantly respiratory infections and diarrheal diseases – and is responsible for the loss of 3.5% of the annual GDP. A different study by World Bank (2014) determined that the air pollution in Dhaka, primarily from the textile and tannery industry accounts for an annual GDP loss of about 0.5%. The costs associated with environmental degradation, particularly air pollution non-mortality cost is around $370 million annually (Narain and Sall, 2016).

Table 2 Rising problem of air pollution in Dhaka and nearby areas

AQI level	Category	2014	2015	2016	2017	2018
00-50	Very Good	22	25	63	18	15
51-100	Good	86	101	94	113	74
101-151	Caution	62	66	68	89	76
151-200	Unhealthy	57	54	30	52	50
201-300	Very Unhealthy	22	53	53	44	80
301+	Extremely unhealthy/hazardous	86	66	46	49	67
>15	Number of days	165	173	129	145	197

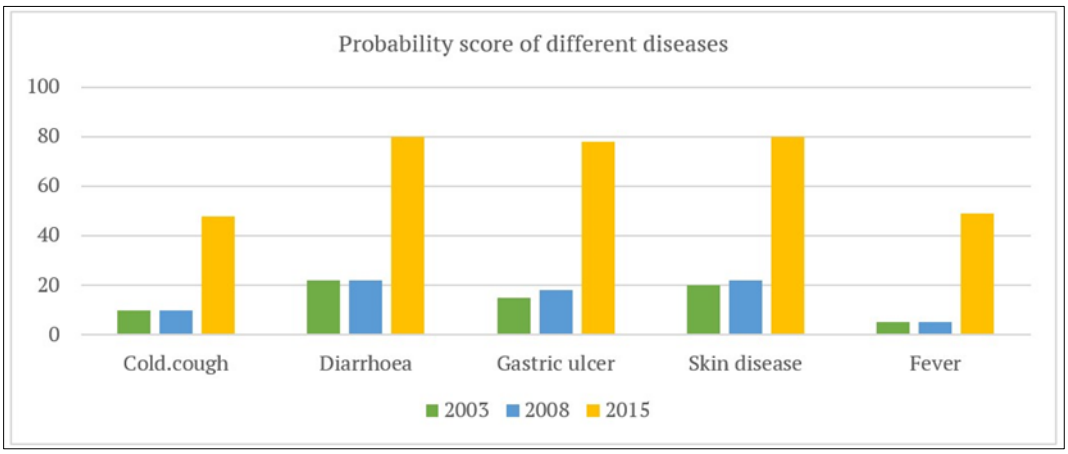

Figure 3 Rising trend of diseases

4.7. Effect on Human Health and Living Standard

Apart from environmental devastation, effluents of (T&A) have catastrophic effects on human health and overall living standard of the workers and surrounding inhabitants (Hoque et al., 2018). A household survey indicates that the incidences of diseases such as jaundice, diarrhea and skin diseases are at least two times higher in the villages and the peri-urban populations, where the textile factories are heavily clustered (Khatun et al., 2013; Ullah et al., 2006). Ali et al. (2008) find that around 36.7% of the (T&A) industry workers are experiencing some sort of poor health, while 70.0% suffering from headaches. Another evidence of the decreasing trend of diseases; for example, in Figure 3, there is a rising trend among diseases in the most populated and textile factory intensive areas in Dhaka and neighboring districts (Halder and Islam, 2015).

The rates of people suffering for various diseases have greatly elevated than in 2003 due to the environmental degradation worsened (Figure 3). Year after year, the environmental condition kept deteriorating as no significant preventive action was taken to ameliorate the status of the environment. According to Halder and Islam (2015) when they interviewed the doctors and health workers working in the relevant areas, unsafe water and pollution of air were the most involved factors behind this trend of increasement of diseases. Even more alarming, a field survey with textile workers in different areas of Dhaka revealed that the closest settlement of (T&A) factories in Dhaka, Gazipur, and Narayanganj left workers deprived of all essential facilities such as adequate living space, fresh air, drinkable water, sanitation, and a space for privacy (Bhuiyan, 2012). As Paul-Majumder (2003) identifies, the hazardous physical environment of the textile factories combine to result in a high level of reported psychological stress and negative mental health among workers. Steinisch et al.2022 dilated a cross-sectional epidemiological study, which reported the prevalence of caries and obesity in children aged 5-12 years. (2013), determines that the aggregation of (T&A) factories in a certain area has an adverse impact on the health of its workers in both the long and short-run.

Recommendations

Thus, it is a necessity and also an opportunity for Bangladesh to pursue green growth which is sustainable for both people and nature in the long run as socio-economic cost of the mind-blowing but poorly planned (T&A) industry is overwhelming. But, such paradigm shift in the way of policy intervention and physical decentralization of the industry is not an easy target to achieve and it executes wide, strategic and multi-stake holder restructuring by the part of Government, private sector, civil society and the investors as well. Recommendations may be applied as framed in Table 3 to bring a change in holistic manner from policy formulation to public awareness.

Table 3 Recommendations

Recommendations	**Responsible sectors/stakeholders**	**Timeline**	**Possible outcomes**
Reforming industrial policy: Present industrial policy does not fully address emerging challenges of environmental pollution caused by T&A industry. In a bid to make this sector moving forward in a sustainable & environment-friendly way, current industrial policy has to be redefined with clear action plans & visionary goals. Policy & guidelines should address relevant environment pollution related policy, regulatory gaps, & flaws so that no loophole is abused by factory owners.	-Ministry of Environment -Department of Environment -Ministry of Industries -Planning Commission -Leading private sectors	Medim & long	A policy platform for protecting environment will be recognized, which will make production processes more efficient & environment friendly.
Strict enforcement of existing environmental laws & penalties: Environmental laws in Bangladesh are not rigidly enforced as current penalty system does not provide an effective deterrence & it requires an overhaul. Along with other laws, 'polluter pays principle' mentioned in section 7 of 1995 ECA	-Department of Environment -Environmental Courts -Special Environment Tribunal	Short	Once penalty for violating environmental laws is strictly applied, factory owners will be more careful & avoid potential punishment.

should be properly applied.			
Making research data available: Necessary research data both from factory owners & government institutions must be made available in their offices & websites so that comprehensive research can be conducted by government agencies & individuals time to time to improve operation & maintenance of apparel industries.	-Bangladesh Garment Manufacturers & Exporters Association -Department of Environment -Ministry of Environment	Short, medium, & long	Making relevant information & data available will render production & operation system transparent. Owners will avoid illegal & harmful means of production process for fear of prosecution.
Relocation of T&A industries: A complete decentralization of textile industries is a demand of time given fact that more than 70.0% T&A factories are clustered in Dhaka & nearby cities. Having such a large number of factories in a few districts is environmentally, socially, & economically detrimental. So, the Government must introduce policies to make factory owners shift & relocate their industries to other district, where industrial density is lower.	-Private T&A owners -Ministry of Finance -Ministry of Planning -Ministry of Environment -Department of Environment -BGMEA	Long	Stress on environment in highly clustered areas within Dhaka & nearby districts will be reduced. It will positively impact public health by reducing environmental pollution. This will also help balancing distribution of economic benefits for people of other districts.
Strengthening monitoring & evaluation: Monitoring & evaluation structure in Bangladesh are weak & inadequate due to insufficient number of workforce & corruption. To bring change in this aspect, number of inspection officers has to be increased as well as their inspection has to be cross-checked so that officers do not make illegal deals with factory owners.	-Department of Environment -Environmental Courts -Ministry of Environment -Ministry of Industries	Medim	Proper & timely monitoring will reduce number of violations, which will result in healthy industrial operation.
Environmental policy integration: Environment is a cross- sectoral issue & thereby it entails multi-scale efforts from a number of sectors like fisheries, agriculture, water resources, industry, & environment. A comprehensive policy with environmental priorities must be formulated.	-Ministry of Environment -Planning Commission -Department of Environment -Ministry of Industries	Long	It will initiate a clear guideline & roadmap for setting up new industries. Also, existing industries will be guided to retrofit poorly & inefficiently functioning apparel factories.
Make environmental impact assessment effective: In Bangladesh, it is required to have a feasibility study & environmental impact assessment if project falls under 'red' category. As T&A industry falls under red category, environment impact assessment must be rigorously maintained before a clearance certificate is issued.	-Ministry of Environment -Planning Commission -Department of Environment -Ministry of Industries -Project Director -Industry Owner	Medim	Making environmental impact assessment mandatory will reduce number of harmful industries. Also, it will ensure safeguard policies for approved projects & industries on part of factory owners, which will benefit environment.
Requiring ETPs: Lack of ETPs & their inefficient functioning are main drivers behind massive load of untreated effluents that cause irreparable damage to environment & human health. So,	-Department of Environment -Local Public Administration	Short	Detrimental impact of effluents on environment & human health will be reduced. Water, soil, & air will be far better in quality, which will

installation of ETPs & their maintenance must be made mandatory.	-Department of Environment		have positive impacts on public health & aquatic species.

5. Conclusion

(T&A) industry growth in Bangladesh is marred by poor planning and lack of vision. Pursuing a fast and growth-oriented development regimen, Bangladesh had failed to give potential environmental problems the due attention early on. Not only was it obsessed with rapid growth, but it could not afford to do so with the large population and the fragile economy it inherited from British and Pakistan regimes. Thus, the country was heavily impacted in its growing phases by the social and economic conditions.

As a developing country, Bangladesh had relatively to work harder to fasten up economic growth, reduce poverty, and solve unemployment while achieving its development targets. So, in a dilemma, decided to create the T&A industry and it worked surprisingly well in a short time, taking advantage of a competitive edge: low labor costs and available power supplies. T&A has remained to be the most reliable and largest export-earning source to the country for more than 30 years. But, one-dimensional attention on economic expansion has resulted in tremendous social and environment consequences over the years. One of the most visible issues that has provided one of the greatest challenges for the country in recent years. Also how, despite the tremendous assistance of the T&A industry in obtaining economic development, T&A relevant environmental hurdles have posed a substantial risk on natural ecosystems and the environment. But, as the T&A industry has contributed massively, the nation cannot take a step back and will not do so either. Instead, transforming them into a sustainable and eco-friendly way of operating is a most profitable solution that does not cause damage to the industry and environment and public health. So, it's time to take a hard look at the entire system, top to bottom. To this end, adopting policies and then the relocation of the already highly clustered factories to safer areas with a clear time bound action plan along with the transformation of the way they operate by using green energy are the most prioritized set of projects to work on. Emerging framework for mainstreaming an environmental agenda through a national development plan, climate change strategies, framework for pollution control across sectoral issues and plans of government has begun, though so far progress and compliance remains slow in Bangladesh. The Government has to fast track this process by forming a large consensus of stakeholders. Certain industries are already being relocated out of the capital. Recently, the tannery industry was shifted out of Dhaka City which will hopefully be followed by decentralization of such other industries like T&A. But for T&A industry, location change is not the lone solution; rather a complete shake-up in their energy usage, effluent treatment, water use, and above all, their entire production process must be holistically resolved. This can only be accomplished if the government of Bangladesh does its best to ensure that the dual objectives of economic advancement of the country and the preservation of the environment and health of T&A industry residents, and the general population surrounding them. This quandary of finding the sweet spot between economic livelihood and enterprise profitability, on one side, and human health and wellbeing, on the other, is a global issue. However, to preserve this vision in everyone's mind and also to be implemented by real life, the government of Bangladesh must engineer some visionary and realistic plans to combat the existing as well as foreseeable challenges in the following decades. In fact, for cleaner production process and sustainable environmental protection, sustainable T&A industry can be achieved through resilient growth. This research is truly hoped that, it would give some idea, and insights to the concerned ones, in tackling a converged solution to the environmental challenges faced by the T&A industry of Bangladesh, so that it can walk along the path of green growth with a sustainable development approach to contribute towards global brightness in the forthcoming decades.

Compliance with ethical standards

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