The Impact of Industrialization on Environmental Sustainability: A case study in Gampaha district

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Abstract

This study is based on impact of industrialization on environment sustainability in Sri Lanka. Objectives of this research are to identify the impact of industrialization on environment sustainability and to provide recommendations to mitigate the damages. Research questions are how does the industrialization impact on environment? And what are the actions which can be taken to mitigate the impact on environment due to industrialization? The research methodology contains mixed method consisting both qualitative and quantitative approaches and interviews have been conducted by the author in order to collect information and analyze them while raw data was collected in aid of analyzing through quantitative approach. Industrialization has become one of the major concerned issues for the sustainability with the dramatic growth of environmental pollution. Environmental sustainability is crucial when it comes to the survival of living being on the planet we all live in. Environmental sustainability talks about sustainable practices that support long-term economic growth without negatively effects social, environmental, and cultural aspects of the community.

Keywords: *Environmental Pollution, Environment Sustainability, Industrialization, Sustainability*

1. Introduction

1.1.Background of the study

Sri Lanka is an Island which is located in Indian Ocean and population approximately about 21 million. (Department of Census and Statistics-Sri Lanka 2012). Contribution to the Gross Domestic Product (GDP) by sector amounts 7.8% from agriculture, 30.5% from industries and 61.7% from Services (Central Bank of Sri Lanka 2018).

The Industry Sector has a long history where the British ruled Sri Lanka in the 20th century. In the early part of this century, there had been factories for processing Tea, Rubber and Coconut, a brewery, tiles, and bricks tea chests in a few other areas only. In 1977 government of Sri Lanka changed their trade policy to open economic policy where importers and exporters could decide what to import and what to export with

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minimum restrictions (Silva 2019). It can be identified as the boom of industrialization in Sri Lanka. Although 30 years of civil war impacted considerably to the growth of industries, in present times, it has become 2nd largest contributor to the economy after the service sector.

Sustainability has become one of the major concerned issues for the industries with the dramatic growth of environmental pollution and public awareness of these in the global level. Rapid industrialization by state and private sector organizations has led to new ways of pollution. In present, soil erosion, coastal degradation, loss of wildlife habitats, waste disposal, water pollution, urban air pollution, marine pollution and hydrological and climate changes are some of the alarming problems that the Sri Lanka has to face. (Zubair 2001)

According to the Directory of the Prescribed Industries/Activities under the National Environmental Act, in Gampaha District there are about 5391 (11.5% of total industries) industries registered and it is only second to Colombo district which is about 5832 industries. Therefore, the researcher is aiming to conduct a case study in Gampaha district to identify the impact of industrialization on environmental sustainability.

1.2. Problem Statement

1.2.1. Motivation of the Study

In Sri Lanka, industrial sector is contributing to the economy as much as 30% to the Gross Domestic Production (Central Bank of Sri Lanka 2018). Reduction in unemployment level in Sri Lanka happened due to the evolution of industries. Although industries are playing a major role in the country's' economy, there are some areas that should be taken into consideration.

Deforestation, contaminating water resources, carbon emission and disposing industrial waste to the environment are some of the concerned issues in Sri Lanka. Environment pollution due to the industrial activities are as high as the pollution due to the urbanization. For an instance, the recent incident in Rathupaswala, where a company called venigros (pvt) ltd. was manufacturing rubber products and disposed their waste led contaminating water resources around the area. Eventually, this water crisis amounts to a number of valuable lives.

Sustainability of the economy in a particular country heavily depends on its environment. Use of natural resources and protect them for future consumption is one of the key drivers for sustainability. If the stability of the environment breaches due to human actions, it will adversely impact on the existence of the human beings. Hence the researcher has identified that it is important to find out the impact of industrialization on environment sustainability.

1.2.2. Research Objectives

- To identify the impact of industrialization on environment sustainability
- To provide recommendations to mitigate the damages to the environment sustainability

1.2.3. Research Questions

- How does the industrialization impact on environment?
- What are the actions which can be taken to mitigate environment impact due to industrialization?

1.3. Significance of the study

1.3.1. Empirical Significance

According to the found details, the impact of industrialization on environmental sustainability has been done by many researchers. Some of them are Rasmi Patnaik (Institute of Management Technology – Nagpur) has done a research on Impact of Industrialization on Environment and Sustainable Solutions – Reflections from a South Indian Region (Research Gate 2019), Effect of Industrialization on Environment (Indian Scenario) by Deepika Bhandari (Independent researcher) (Research Gate 2019).

But there is no evidence that this type of research done in Sri Lankan context. Gampaha District has the greatest number of industries after the Colombo district (Central Environmental Authority 2016) and also one area which has been affected heavily from industrialization. Therefore, the researcher has identified the empirical significance and conducted the research on Impact of the industrialization on environmental sustainability in Sri Lanka focusing on Gampaha District.

1.3.2. Practical Significance

This research will be significant to many parties such as, Central Environmental Authority to take decisions on environmental pollution, Sri Lankan government can get the necessary information when making environmental policies, industries can rethink about their waste disposal and waste management systems, general public around the industrial zones will be heavily benefited and most importantly the environment will be protected to the future generations.

2. Literature Review

2.1. Industrialization

Industrialization can be defined as the increase in industrial activities of an economy. (Treiman 2010) It is believed that industrialization would lead to development of the economy in the long run. Increase in the employment rate, competition within an industry, tax revenue, technology advancements are some of the key features of

industrialization that would lead to the economic development (Raheem & Ogebe 2015).

2.1.1. Factors of industrialization

According to the United Nations Industrial Development Organization (2017) factors of industrialization are Technology, Infrastructure, Capital Investments and Labour. These 4 factors can be further discussed as follows:

Technology: Application of science to industrial or commercial uses refer as the technology in Industrialization. Manufacturing processes were mechanized due to number of inventions in 19th century. Also, it helped to increase efficiency and productivity (Robinson, 2008)

Infrastructure: Infrastructure is key element in industrial development. Economists call infrastructure as combined network of transportation and communication. It is considered as the foundation and framework of economic growth. The roads, railroads, waterways, bridges and canals were developed in the 19th century which help to make a vital link to Industrialization.

Capital Investments: Capital investment can be defined as the amount of money spend by a company to achieve its business objectives. It also refers to the acquisition of long-term assets such as machinery, manufacturing plants, real estate etc. by the company. (Investopedia, 2019)

Labour : Human element of the industrialization referred as the labour. Many labour-intensive productions were carried out in the factories in early days. This human element also included the entrepreneurs and people who provided financing, organizing materials and workers, control operations etc. (Cornwall, 2002). Worker's education, skill level and motivation are the key factors of deciding the value of labour force. That is the deciding factor of how much of labour hours each worker contributes to the output.

Table 2.1: Summary of factors of Industrialization

Technology	• Application of science to industrial uses
Infrastructure	• Roads • Water supplies • Electricity
Capital Investments	• Refers to the money and the factories themselves • Space
Labour	• Workers • Leadership • Entrepreneurship

Source: Developed by Author

2.2 Negative Impacts of Industrialization on Environment

When considering the other sides of the industrialization environment degradation can be seen as one of the concerned issues. Some industries would demand more energy so that it leads to deplete the natural resources (Ying Shin 2015). Some of the major challenges faced by the present generation are climate changes, energy security crisis, global warming, deforestation and rising sea level which are caused by the environmental degradation. Industrialization plays a big role in aforementioned challenges. The impact of industrialization has led to certain positive and large number of negative outcomes. Contaminating water resources, air and soil pollution can be identified as the by-products of economic development in industry. (Hassan 2017)

2.2.1 Sustainability

The term sustainability refers to the capability of maintaining over the long run. (Manderson 2006) The concept of sustainability can be elaborated with three overlapping circles representing economic, social and environmental dimensions. The economic dimension symbolizes the system of producing, distributing, and consuming wealth. Social dimension symbolizes the system of living and importance of the maintaining and improving living standards. The environmental dimension symbolizes the system of providing integrity and preservation of eco systems. (Herremans & Robin 2002)

A. Economic Sustainability

The economic dimension of sustainability concerns the organization's impact on the economic conditions of its stakeholders, and on economic systems at local, national, and global levels. The Economic Category of the sustainability illustrates the flow of capital among different stakeholders, and the main economic impact of the organization throughout society. (Mairal, 2015)

B. Social Sustainability

Social sustainability is about identification and management of both positive and negative business impacts, on people. (Karbassi, 2019) The quality of a company's relationships and engagement with its stakeholders is critical. (United Nations, 2019)

C. Environmental Sustainability

According to Hemarn Daly (1990) who is one of the pioneer of ecological sustainability defined that "Environmental sustainability is the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely". The practice of environmental sustainability helps to ensure that the needs of today's population are met without limiting the ability of future generations to meet their needs. (Daly 1990)

2.2.2 Factors of environmental sustainability

According to Daly (1990) factors of environmental sustainability can be described as follows,

A. Natural resources

Natural resources are components that exist in the world without the human input. Most natural resources are limited. This means they will eventually run out after a period of time. Natural resources are essential to the survival of humans and all other living organisms. (Balaras , et al., 2002) All the products in the world use natural resources as their basic component, which may be water, air, natural chemicals or energy. Natural Resources can be further divided into two parts as renewable resources and non-renewable resources.

B. Pollution Creation

Pollution creation is the introduction of harmful materials into the environment. These harmful materials are called pollutants. Pollutants damage the quality of air, water, and land. (National Geographics , 2019) Although environmental pollution can be caused by natural events such as forest fires and active volcanoes, use of the word pollution generally implies that a source is created by human activities.

2.3 Research Gap

Researches on the impact of Industrialization on Environment Sustainability focus on Gampaha District, Sri Lanka has not yet been clarified. Therefore, the purpose of this study is to contribute to the new knowledge. In past, Sri Lanka is based on agricultural economy but it can be seen in present that industrial and service sectors are contributing the economy more than the agricultural sector. Sri Lanka is considered as a developing country and the country is industrializing in a rapid rate. The number of projects and industrial zones are increasing day by day. Hence it is very important to identify the impact to the environment before it becomes a major issue to the environment as well as to the country. Further, this study is focusing Gampaha district, because the selected area has been industrialized to a greater extent. And also, this study's outcomes will be benefited to the whole nation.

3. Conceptualization and Research Methodology

3.1 Research Approach

For this this study a mixed of qualitative and quantitative approaches have been used. An explorative research have been carried out in the areas of industrialization and environment sustainability in Sri Lanka. For carrying out the research certain industries in Gampaha district and government agencies have been targeted. It has been executed through face to face in depth interviews and field visits followed by self-administered questionnaire.

3.2 Conceptual Framework

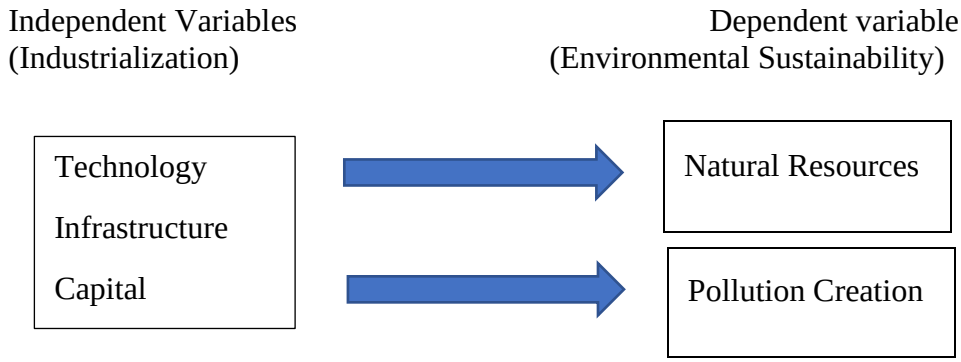

Figure 3.1: Conceptual diagram

Source: Developed by Author

3.3 Developed Hypotheses

H1: There is a significant relationship between technology and Natural resources

H2: There is a significant relationship between infrastructure and Natural resources

H3: There is a significant relationship between capital and Natural resources

H4: There is a significant relationship between technology and Pollution creation

H5: There is a significant relationship between infrastructure and Pollution creation

H6: There is a significant relationship between capital and Pollution creation

3.4 Population and Study Sample

The researcher has chosen a representative population which is local residents who are living around the industrial zones in Gampaha District. In this research, purposive sampling was utilized to select cases with specific purpose and have a very specific need in mind. Sample was limited to 50 local residents who live around the Mirigama Export Processing Zone. (Appendix 1)

3.5 Data collection

Secondary Data : Information on the selected subject area, have been collected from Central Environmental Authority and their publications, journal articles, newspaper articles, books, websites and researches related to the subject area.

Primary Data: The data have been collected through face to face in depth interviews with the industries in Gampaha district and government authorities. Apart from that, the researcher has conducted a survey in Gampaha district with 50 local residents who are living around the Mirigama export processing zone.

Table 3.1 Operational table

Variable	Dimensions	Measures	Question No.
Independent variables	**Technology**	Improve Living Standard Development of the country Impact on community culture	1 2 3
	Infrastructure	Road systems Water supplies Electricity facilities Urbanization Business Opportunities Increase the efficiency	4 5 6 7 8 9
	Capital Investments	Amount of space allocated Acquisition of lands	10 11,12
Dependent variables	**Natural Resources**	Use of renewable resources Depletion of natural resources Environment management plan	13,14 15 16
	Pollution creation	Clean and Healthy environment Environmental pollution Pollution mitigation actions	17 18,19,20,21,2223, 24

Source: Developed by author

4. Data presentation, Findings and Discussion

Since the researcher conduct the research in both qualitative and quantitative approaches, research has been conducted in mixed method. Qualitative research approach was conducted focusing on Government and Environmental Authority (GEA) and the Quantitative approach was focused on general public who have been affected by the industrial activities. Survey questions and interview questions were prepared based on the research variables. They are technology, infrastructure, capital investment (independent variables) and sustainability, environment pollution (Dependent variable)

4.1. Qualitative Data Analysis

Two questionnaires were prepared in order to get the details from industries and central environment authority. Ten people representing different BOI Industrial Zones in Gampaha District were questioned and five people representing three different organizational levels (Director/ Assistant director/ officers) were questioned with the objective of getting the answers for the research questions. Since the interviewed persons were reluctant to reveal their identities, their names are not mentioned in the research study.

A. The impact of Industrialization on Technology

When an industrial zone is established the area become more urbanized and efficient. People around rural areas also receive the benefits of living more comfortable lifestyles. Especially the electricity and telecommunication facilities are developing with industrial zones. Therefore, technology can be seen as one of the main variable under industrialization.

Based on that, a question was asked "How does the technological development due to industrial zone, has increased the living standard of the households around the industrial zone"?

The Senior Deputy Director – Engineering in one of the BOI zone mentioned, *"We built a grid substation for electricity in the zone which have the capacity of 60 Megawatt and we only consume 45 Megawatt. So that we could provide extra 15 Megawatt for the houses which are around the zone and it results into improve the electricity facility in the area. Further, we have the fiber optic technology (telecommunication) inside the zone, after we receive the fiber optic people around the area also receive the opportunity to get the fiber optic service easily".*

It is evident that when an industrial zone is established, people around the area receive various kind of benefits with the technological advancement in the area. Hence it can be concluded that technological development due to industrialization is positively impact on the area and the people.

B. The impact of Industrialization on Infrastructure

Infrastructure development: The first question under the infrastructure variable was "What types of infrastructure development have been occurred in the area with the development of the industrial zone"? A Zone Director in one of the BOI zones emphasized,

"We built a common water tank which supplies water to the zone and also to the villagers. And also we provided some space from zone for water transmission line which supply the water to the village. Other than that built some street lamps from the zone to the village. Further we have a separate road system for the zone but we

developed some roads around the area since most of our workers live in the nearby villages, so they can travel easily.

According to the research information, it can be seen that there are various kinds of infrastructure development have been occurred due to industrialization. As it mentioned by the zone director basic human needs such as water, electricity and road systems have been developed with the industrial zones.

Job and Business opportunities:

The second and third question under the same variable was "What type of job opportunities and business opportunities people in the area received after the industrial zone was incorporated? Zone Director in one of the BOI zones answered,

"*Most of the low-level workers who work inside the zone are hired from nearby villages. So, they receive number of job opportunities with the zone. We also give priority to people who live nearby areas. We have various types of manufacturing industries inside the zone. Most of them are labour intensive so there are ample job opportunities are available".*

"When talking about the business opportunities, people around area receive indirect and direct business opportunities with the zone. There are number of boarding houses and restaurants /canteens have been started in the area after the industrial zone was incorporated because thousands of workers come each day to this particular area. Other than some of the industries buy some of the raw materials from the nearby areas. Further, we have a dump yard inside the zone, people around the area can get recyclable waste (Glasses, cardboard etc.,) from the material sorting bay and they use to sell those material to different parties. With that they receive another indirect business opportunity".

It is evident that most of the people who live around the industrial zone received different kinds of job opportunities since most of the factories are human intensive. Specially, there is a high demand for the lower level employees. Further, Indirect and direct business opportunities have been created with the development of the industrial zones.

Urbanization:

Final question under infrastructure was "Does the area became more efficient and urbanized after the industrial zone was incorporated? Zone Director in one of the BOI zone responded to that question,

"Yes of course, after the industrial zone was incorporated lots of private sector organizations, businesses and number of banks have been established in the area. With that lifestyle of the people around the area became more comfortable."

It can be seen that one of the positive impacts of industrialization is, rural areas become more efficient and urbanized with the development of the industrial zones. Further, it will positively impact on country's economic development.

C. The Impact of Industrialization on Investments

The questions under capital investment variable were "What type of indicators are being used when selecting a suitable location to build an industrial zone and what types of rules and regulations to be followed?" Responded by a deputy zone director in one of the BOI zones,

"Mainly we consider the accessibility to the location. Specially we the distance to the harbor and airport are taken as main indicators. Other than that we also consider the infrastructure facility in the area. Road system, water supplies and electricity are the main indicators of the infrastructure. Further, we also consider the ways of disposing industrial waste. And also we have to do an Environment Impact Assessment (EIA) and have to take the approval from CEA".

When the researcher asked the same question from CEA "What types of environmental rules and regulation should be followed when initiating a new zone or selecting suitable location" respond from the, Director Compliance monitoring Unit - CEA can be analyzed as follows:

According to the Director, ***"****When an industrial zone or an industrial plant establish, there are three types of license that should be taken by the industries under 1980 No.7 National Environment Act. Some of the licensee should be taken after initiating the business. Further in Gampaha District only the Biyagama and Katunayake industrial zones have carried an Environmental Impact Assessment (EIA). You can reduce number of environmental issues with EIA but other zones have number of serious issues because they didn't go through an EIA process when establishing the industrial zones"*

Those three licensees or the regulatory tools of the CEA can be summarized as follows:

Table 4.1: Regulator tool of CEA

Regulatory Tool	**EIA**	**EPL**	**SWML**
Gazette notification	No. 722/22 (1993.06.18)	No. 1533/16 (2008.01.25)	No. 1534/18 (2008.02.01)
License Issuance	Prior to start the project	After starting the business	After starting the business
Covered Areas	Environment Impact	Wastewater Standards, Noise, Source Emission, Interim Standards	Solid Waste

Source: Compliance Monitoring Unit, CEA

According to the research details it is evident that industrial zones have number of criteria to check before establishing a zone. When considering the environment regulations considerable amount of industries have failed to achieve the environmental rules and regulations imposed by the CEA. Therefore, as per the CEA details various kind of serious issues have been developed with the time. Although there are good environmental regulatory tools, they are not strong enough to cover every industrial activity.

D. The impact of Industrialization on Natural Resources

- Plantation program

The answer to first and second question under natural resources variable, "Did the Industrial zone carry out a re-plantation programme to cover the lost plants when industrial zone was built? And how do you maintain those plantation? These two questions can be analyzed as follows:

Respondent from assistant director – Environment management department in one of the BOI zone mentioned that,

"Most of the time industrial zones are built in large coconut estates or rubber estates. So we have to cut most of the plantation. Therefore, generally we allocate 20% of the total zone area to plant trees and for gardening purposes. . In this zone we have more than 400 acres, so 20% means it's almost 80 acres we have been allocated to the

plantations. In that 20% area we don't give permission to establish any kind of industries. As you walk through the park you can see lots of greenery area have been maintained. To maintain the plantation, we have separate gardening unit and we also use waste water which have been purified by the waste water treatment plants."

Therefore, it can be concluded that the industrial zones are concerning on sustainable initiatives by replantation programs and maintaining those plantations. As per the details, 20% of the total zone area can be seen as large area considering the amount of space allocates to the total zone.

- Depletion of natural resources

Third question under the variable was, "Do you believe that natural resources have been depleted by the industrial zone activities? (Ex – Reducing the water level in the area) Respondent from one of the officers (Environment management) in one of the BOI zone mentioned,

"Specially, water requirement of the zone is supplied by the national water board and it is the main water source (around 90%). Other than that we use few tube wells (around 10%) but there is no impact to water resources around the area because we didn't get any complaints from the general public or the CEA". We monitor every activity performed by the individual industries and take necessary actions if there is anything going against the environment. Therefore we take every possible action to minimize the damages to natural resources and protect the environment."

Based on the above answer, it can be seen that, there can be pollutions but there is no considerable depletion of natural resources have been occurred due to industrial activities.

- Renewable resources

Fourth question under the same variable was "What types of renewable resources are being used by the industrial zone?" Respondent from one of the officers – Environment management department in one of the BOI zone mentioned that,

"Though we supply electricity to each of the industrial plants, some of them are using considerable amount of solar power to generate electricity. And also some of the plants have rain water harvesting systems. Other than that BOI zone have a good waste water treatment plant. We collect waste water from each industrial plants inside the zone through a drainage system and we purify them according to the national standards and dispose to a nearest river. The best part is we use considerable percentage of the purified waste water for our irrigation and gardening purposes. That's the how we mainly use renewable resources."

It is evident that industries are concerning about renewable resources and there is a positive trend towards sustainable energy. Further the environmental impact also can be reduced with the consumption of renewable resources.

- Environment Management Plan

Fifth and final question was "Does the industrial zone have an environment management plan? Respondent from assistant director – Environment Management Department in one of the BOI zone mentioned,

"There are set of environmental standard specially designed for BOI zones called "environmental norms". Every industrial plant inside the zone have to adhere to those standards and policies mentioned in that particular document. We monitor every actions taken by the industries inside the plant and check whether they are following the rules and regulations mentioned and take necessary actions"

It is evident that BOI industrial zones are maintaining a high standard about the environment. But there may be some issues when practicing those regulations. Having a good environment management plan reduce considerable amount of issues which can be occurred.

E. The Impact of Industrialization on Environmental Pollution

Environmental pollution due to industrialization is the main factor that the researcher is focused on with this research. In order to get the idea about industries that are directly impact on environmental pollution researcher questioned, "How do you identify and categorize the industries which directly impact on environmental pollution"?

The respond from the director of research and development – CEA as follows: "*We classified all the industries under 3 categories as "A","B" and "C" depending on their pollution potential.* ***Part "A"*** *comprises of significantly high polluting industrial activities and* ***Part "B"*** *comprises medium level polluting activities* ***Part "C"*** *comprises low polluting industrial activities*"

Below table and maps can be referred to get a further knowledge and number of industries in Gampaha District:

Table 4.2: The Summery of Prescribed Industries/ Activities in Gampaha District

DSD	A' Category	B' Category	C' Category	BOI	Total
Attanagalla	130	74	159	40	**403**
Biyagama	193	115	180	31	**519**
Divulapitiya	194	196	182	31	**603**
Dompe	194	61	157	13	**425**
Gampaha	144	87	128	9	**368**
Ja-Ela	228	107	81	44	**460**
Katana	173	96	246	49	**564**
Kelaniya	141	67	73	15	**296**
Mahara	136	117	144	20	**417**
Minuwangoda	109	91	255	19	**474**

Table 4.2: Cont'd

Mirigama	136	107	179	21	**443**
Negombo	85	99	161	15	**360**
Wattala	239	68	88	43	**438**
Total	**2102**	**1285**	**2030**	**350**	**5767**

Source: Research and Development Department, Environmental Authority

According to the above research details, it can be concluded that CEA has an overall knowledge about the different kinds of industries operates in each district in Sri Lanka. Above maps and table show that how industries are distributed in the Gampaha district and the impact on the environment based on industrial category.

- Water, Sound and Air Pollution

To get the knowledge about different kinds of pollutions due to industrial zone activities researcher asked, "Do you believe that water resources, air and sound have been polluted with the industrial zone activities? Responded by one of the officers – Environment Management Department in one of the BOI zone mentioned,

"As I said we have to adhere to the environmental norms issued for BOI zone. Therefore, we don't think that there is any considerable environmental pollution happening around. There can be various complaints from the general public, but we can assure that there is no serious pollution is happening due to industrial zone activities since we adhere to our environment policies"

But when interviewing CEA officers, number of serious pollution incidents in Gampaha District have been collected. They can be summarized as follows:

Table: 4.3 – Complaints relating to different Industrial Zones

Industrial zone	**Complaint**
Wathupitiwala	One of the companies inside the zone produce some high noise and it disturbs to the households around the area.
Katunayake – Stage 3	Air pollution due to burning aluminium by one of the industries inside the zone
Nittabuwa	Improper disposing package waste and wastewater
Mirigama	Air pollution due to battery recycling industry

Source: CEA Gampaha Division

As per the research details it can be concluded that, though the BOI emphasized that there is a minimal environmental pollution, according to the CEA there are significant issues around the BOI zones. Therefore, it is evident that there are numerous ways of pollution are occurring with industrial activities.

- Industry monitoring process

Next question on the same variable was "How do you monitor the industrial activities"?

Responded by one of the officers (Environment management department) in one of the BOI zone mentioned that,

"We have a daily routine schedule to monitor the industrial activities and we check whether each industry adheres to our environmental norms and we take necessary actions based on that"

When the same question asked from CEA, an officer in Gampaha District Division mentioned that,

"We monitor the industrial activities before EPL is issued. Other than that we monitor them when a complaint received and at renewal of EPL. Further, we have a monitoring system based on the industry category, because we can't wait till the industries renew their license. But the problem is with our current monitoring system we can only achieve 30% of the target because of the lack of capacity"

Below table shows how EPL is issued and industrial activities are being monitored,

Table 4.4: Environment Protection License (EPL) based on Industry category

Industry category	**A**	**B**	**C**
Issuing EPL, follow-up, monitoring and law enforcement	District Offices of the CEA	District Offices of the CEA	Local Government Authorities, namely Municipal Councils, Urban Councils and Pradeshiya Sabhas
Validity Period	1 year	3 years	3 years
Monitoring period	Every 6 Months, at the renewal of the license or when a complaint is received	Every 12 Months, at the renewal of the license or when a complaint receive	At the renewal of the license or when a complaint receive

Source: Compliance Monitoring Unit, CEA

Although, BOI is monitoring their industrial activities, CEA also have to monitor them when necessary. CEA have different types monitoring procedures based on the industrial category. But with the limited capacity, it is evident that CEA unable to achieve their targets. Hence some loopholes in the regulatory tools can be created and arisen further problems in the future.

- Industrial waste

The next question was focused on industrial waste created by industrial activities; therefore researcher questioned "how do you dispose the industrial waste"? The assistant director (Environment Management Department) in one of the BOI zone mentioned,

"We have our waste water treatment plant to dispose the water and the solid waste will be disposed through the Holisim Company, because some of the solid waste will be a raw material to them. Other than that we dispose the solid waste through dumping sites in Gampaha District"

The Director Compliance monitoring Unit CEA replied to the same question as,

"We have common waste water treatment plant in Rathmalana and Ekala maintained by National Water Supply and Drainage Board but we need an integrated waste management system to dispose the solid waste. And also still we don't have a proper landfill method to dispose the solid waste currently we advise industries to dispose the solid waste through Dumping sites

According to above details it can be seen that there are different methods to dispose the industrial waste. Currently, disposing waste in to dumping sites can be considered as the most effective method. But as per the CEA there is no sustainable method to dispose industrial waste in Sri Lanka. It can be considered as one of the significant issue faced by the industries and also the government.

- Spreading of Diseases

Final question under the environment pollution variable was "Do you believe that diseases have been spread with the industrial zone activities"

One of the officers – Environment Management Department in one of the BOI zones mentioned,

"There were some minor complaints but currently we don't have any complaints from general public that diseases have been spread with the industrial zone activities"

But when interviewing central environmental authority officer – Environmental Authority Gampaha division mentioned that,

"We received some complaints about Industrial Plant at Mirigama zone which recycle batteries that the plant is disposing some poisonous air and people around area have suffered with breathing problems. And we involved with that problem and advice to the company to take necessary actions to mitigate the pollution"

According to the above discussed details it is evident that industrial activities may harm the people in serious ways. Though the industries are not much concerned about them, there are some incidents happening around the industrial zones. Therefore, diseases which can spread due to industrial activities also should be taken into consideration.

4.2. Quantitative Data Analysis

This chapter contains the presentation of data collected for this study by use of questionnaire and the analysis of data. The researcher will present the data of total 50 respondents who have been participated to the survey. The survey was conducted around the Mirigama Export Processing Zone, Gampaha District.

4.2.1. Cronbach's Alpha Reliability Testing

$$a = \frac{N.C}{V + (N-1).C}$$

Table 4.5 Reliability Statistics

No. of items	Cronbach's alpha	Decision rule	Comment about reliability
24	0.767	0.767>0.7	**Reliable**

Source: Developed by Author

As shown in the (Table 4.5), Cronbach's alpha is 0.767, which is more than 0.7 and it indicates that there is good consistency between data, which measures the variable.

4.2.2. Correlation Analysis

Since there are two dependent variables, two correlation were calculated. The first correlation calculation was done to identify the relationship between, Natural resources (dependent variable) and technology, infrastructure, capital investment (independent variables). (Table 4.6) The Second correlation calculation was done to identify the relationship between, pollution creation (dependent variable) and Technology, infrastructure, capital investment (independent variables). (Table 4.6)

Table 4.6: Correlation of Natural resources

Independent variables	**Dependent Variable**	**Positive / Negative**	**Significance Value**	**Significant or not Significant**
Technology	0.640	Positive	0.000	Significant
Infrastructure	0.611	Positive	0.000	Significant
Capital Investment	-0.453	Negative	0.001	Significant

Source: Developed by Author

Pearson correlation between the Natural resources and Technology is 0.640, which is positive. The significant value is less than 0.05, thus, there is statistical evidence to claim that there is a significant positive relationship between Natural resources and Technology.

Pearson correlation between the natural resources and infrastructure is 0.611, which is positive. The significant value is less than 0.05, Thus there is statistical evidence to claim that there is a significant positive relationship between Natural resources and Infrastructure.

Pearson correlation between the natural resources and capital investment is – 0.453, which is negative. The significant value is less than 0.05. Thus, there is statistical evidence to claim that there is a significant negative relationship between Natural resources and Capital Investment.

Table 4.7: Correlation of Pollution creation

Factor / Value	Pollution creation	Positive / Negative	Significance Value	Significant or not Significant
Technology	0.338	Positive	0.000	Significant
Infrastructure	0.499	Positive	0.000	Significant
Capital Investment	0.590	Positive	0.000	Significant

Source: Developed by Author

4.2.3. Multiple Regression Analysis

Table 4.8: Model summary of regression - Natural resources (dependent variable) and other independent variables

Adjusted R - Square	Significance value of ANOVA	Coefficient values		
0.723	0.000	**Model**	**(B)**	**Sig.**
		Constant	1.014	0.043
		Technology	0.365	0.005
		Infrastructure	0.305	0.002
		Capital Investment	-0.074	0.045

Source: Developed by Author

The adjusted R square value is 0.723 which is significant at 1% (significant = 0.000). The value is 0.723 as a percentage 72.3% of explanatory power is explained here by all three independent variables (Technology, infrastructure, Capital Investment). Further, the regression equation of three independent variables and Natural resources:

Natural resources =1.014+0.365 (Technology) + 0.305 (Infrastructure) – 0.074 (Capital Investment)

Table 4.9: Model summary of regression - Pollution creation (dependent variable) and other independent variables

Adjusted R - Square	**Significance value of ANOVA**	**Coefficient values**		
0.612	0.000	**Model**	**(B)**	**Sig.**
		(Constant)	0.865	0.042
		Technology	0.199	0.049
		Infrastructure	0.260	0.001
		Capital Investment	0.320	0.016

Source: Developed by Author

The adjusted R square value is 0.612 which is significant at 1% (significant = 0.000). The value is 0.612 as a percentage 61.2% of explanatory power is explained here by all three independent variables (technology, infrastructure, Capital Investment). Further, the regression equation of three independent variables and Pollution creation:

Natural resources =0.865 + 0.199 (Technology) + 0.260 (Infrastructure) + 0.320 (Capital Investment)

4.2.4. Hypothesis testing

Table 4.10 Hypothesis testing – Natural resources

Factors	**Standard beta correlation**	**Significance**	**Decision for the hypothesis**
Technology	0.365	0.005	H1: is Accepted
Infrastructure	0.305	0.002	H2: is Accepted
Capital Investment	-0.074	0.045	H3: is Accepted

Source: Developed by Author

H1: There is a significant relationship between Technology and Natural resources.

The impact of technology is positive (0.365) and significant (sig.0.05<0.05) towards natural resources in Gampaha District. Since the beta value is significant H1 is accepted. In terms of technology there is 36.5 % positive influence towards natural resources.

H2: There is a significant relationship between Infrastructure and Natural resources.

The impact of Infrastructure is positive (0.305) and significant (sig.0.002<0.05) towards natural resources in Gampaha District. Since the beta value is significant H2 is accepted. In terms of infrastructure there is 30.5 % positive influence towards natural resources.

H3: There is a significant relationship between Capital Investment and Natural resources.

The impact of Capital Investment is negative (-0.074) and significant (sig.0.045<0.05) towards natural resources in Gampaha District. Since the beta value is significant H3 is accepted. In terms of Capital Investment there is -7.4 % negative influence towards natural resources.

Table 4.11 Hypothesis testing – Pollution Creation

Factors	**Standard beta correlation**	**Significance**	**Decision for the hypothesis**
Technology	0.199	0.049	H4: is Accepted
Infrastructure	0.260	0.001	H5: is Accepted
Capital Investment	0.320	0.016	H6: is Accepted

Source: Developed by Author

H4: There is a significant relationship between Technology and Pollution.

The impact of technology is positive (0.199) and significant (sig.0.049<0.05) towards Pollution in Gampaha District. Since the beta value is significant H4 is accepted. In terms of technology there is 19.9% positive influence towards Pollution

H5: There is a significant relationship between Infrastructure and Pollution.

The impact of Infrastructure is positive (0.260) and significant (sig.0.001<0.05) towards Pollution in Gampaha District. Since the beta value is significant H5 is accepted. In terms of infrastructure there is 26% positive influence towards pollution.

H6: There is a significant relationship between Infrastructure and pollution.

The impact of Capital Investment is positive (0.320) and significant (sig.0.016<0.05) towards Pollution in Gampaha District. Since the beta value is significant H6 is accepted. In terms of Capital Investment there is 32% positive influence towards pollution.

5. Conclusion and Recommendation

5.1. Conclusion

The research has been done with the objectives of identifying the impact of industrialization on environment sustainability and provide recommendations to mitigate the damages to the environment sustainability. Relevant theories related to the topic has been discussed in the literature. Answers to the research question has been discussed in the research analysis. In this research, the researcher has followed a mix of qualitative and quantitative research approaches.

According to the qualitative analysis of the research, technological advancement due to industrialization has impacted positively to the households who live around the industrial zones. With the industrialization, infrastructure of the area has been developed. When considering investment in Capital Investment number of indicators are being used before selecting a suitable location to start industries in a particular area It is evident that industries are concerning about the natural resources but there are some issues when practicing environmental management plans.

It is evident that current monitoring process of CEA is not strong enough to cover the targets with the limited capacity. One of the concern issues in environmental pollution due industrial activities is different kind of diseases have been spread around the industrial zones in Gampaha District.

According to the quantitative analysis of the research, standardized coefficients beta, it is evident that Capital Investment is the most important factor which has negatively impacts on natural resources in Gampaha District. Reason for that may be most of the industries have failed to adhere to environmental rules and regulations on Capital Investment. But other factors (technology, infrastructure) have no negative impact on natural resources. Further, according to the quantitative statistic all the factors (technology, infrastructure, Capital Investment) have positively impact on pollution creation in Gampaha District.

According to the above discussed factors it can be concluded that industries are one of the major factors which helps for the economic development in the country but industries have to be more sustainable in order to mitigate the damages to the environment. Hence, it can be identified that the researcher has successfully answered to the all the research questions and satisfy the research objectives.

5.2.Recommendations

Integrated waste management system to dispose the industrial waste - According to the research details it can be found that, there is no proper way to dispose industrial waste in Sri Lanka. The most effective, current practice of the CEA and Industries is to dump the waste in to dump yard in different locations in the country. But they are not a sustainable solution. Therefore, following recommendations can be given,

More sanitary landfill to dispose industrial waste -Sri Lankan government going to initiate a sanitary landfill program in Aruwakkaru (Colombo page, 2019) for the domestic waste but there is no plan to implement any sanitary landfill program for the industrial waste. Therefore, it is recommended to initiate more sanitary landfill programs to dispose the industrial waste.

Offshore landfilling- As a solution for the constraints regarding the suitable location for landfill, Singapore has successfully launched the World's first offshore landfill constructed from the seabed up is located in Singapore Semakau Island. (Civil engineer Org., 2019). Sri Lanka also can initiate to offer shore landfilling programs if there are no sufficient land inside the island.

Incineration - This is one of the waste treatment technology which covert the waste into to IBM, gases, particles and heat. These products are later used for generation of electricity. (Science Direct, 2019).

- Strong policies, rules and regulations to be imposed on industries

It can be found that most of the industries are failed to adhere to the rules and regulations of the CEA. Specially, CEA stated that most of the industries doesn't have the Environment Protection License.(EPL). Therefore, Environmental Act should be amended and make strong environmental policies rules and regulations.

- **Initiate a proper industry monitoring system in Central Environmental Authority**

CEA current monitoring system have the capacity only to cover 30% of the target. The main reasons for that is lack of employees and the outdated manual process So that it is recommend increasing the number of employees in industry monitoring unit in CEA and implement a more updated and computerized system.

- **Initiate a proper communication system in Central Environmental Authority to solve complaints from general public**

Considerable number of people around industrial zones have complained about the environmental pollution activities done by the Industries. But most of them are not satisfy with feedback from CEA. Therefore, there should be a proper communication system to solve complaints from general public.

5.3. Further Research Studies

The limitations of the study have prompted suggestions for further research as listed below;

- This research has unravelled some ways to exploring industrialization and Environmental sustainability in Sri Lankan context. Further research could explore aspects of sustainability for example, social impact of industrialization, impact on economic development due to industrialization.

- The research is limited Gampaha District. Further research can consider the other district in Sri Lanka or covering the all the districts in Sri Lanka.

- In the quantitative analysis data used for the current study was derived from 50 Local residences who live around the Mirigama industrial zone. Further research can select a larger population and larger sample to collect data.

- In this research study adjusted r squared is 0.723. As a result of that model developed represent 72.3%. Further research can be conducted to the balance 27.7%

- In the qualitative analysis interviews were conducted in industrial zones and Central Environmental Authority. Further research can focus on the general public view on environmental pollution due to industrialization.

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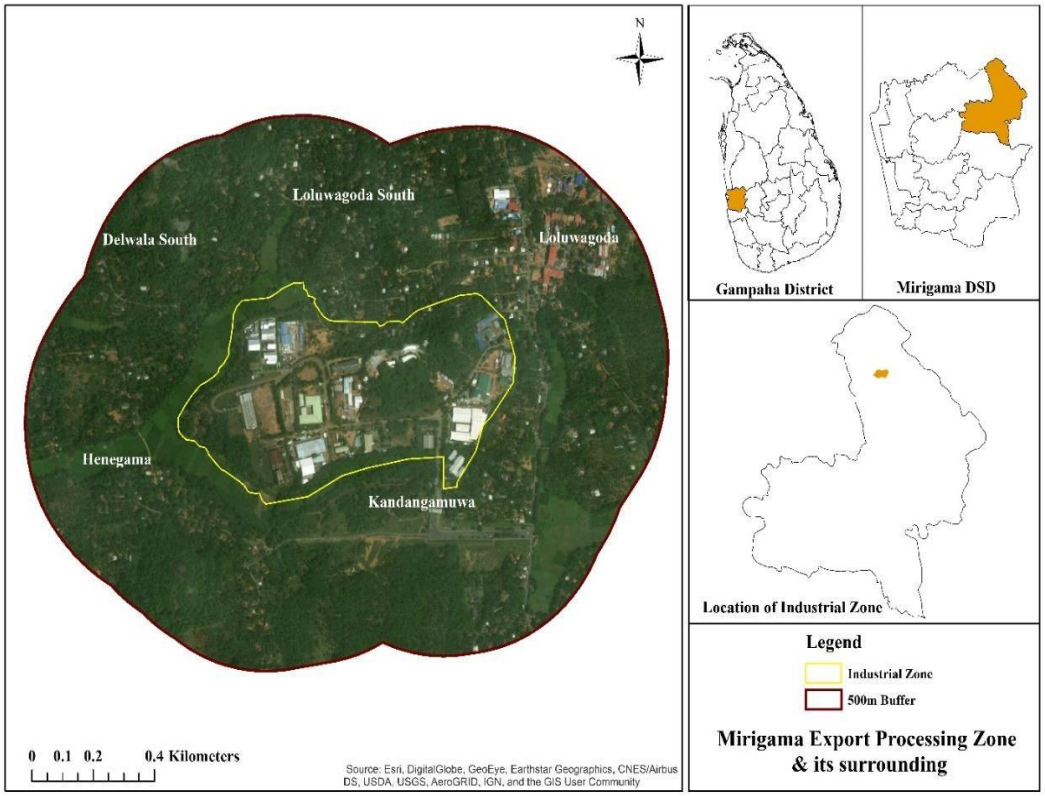
Appendix 1

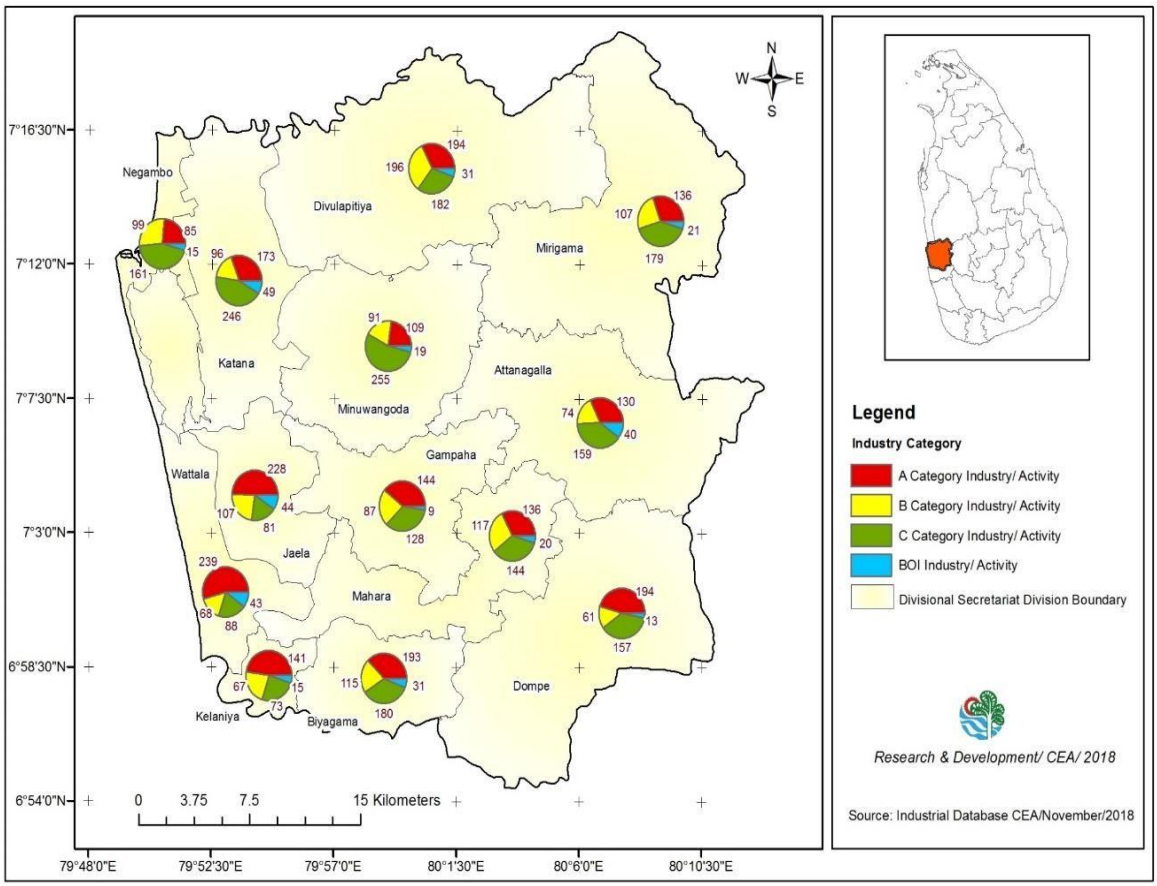
Mirigama Export Processing Zone



Source – Central Environmental Authority

Appendix 2

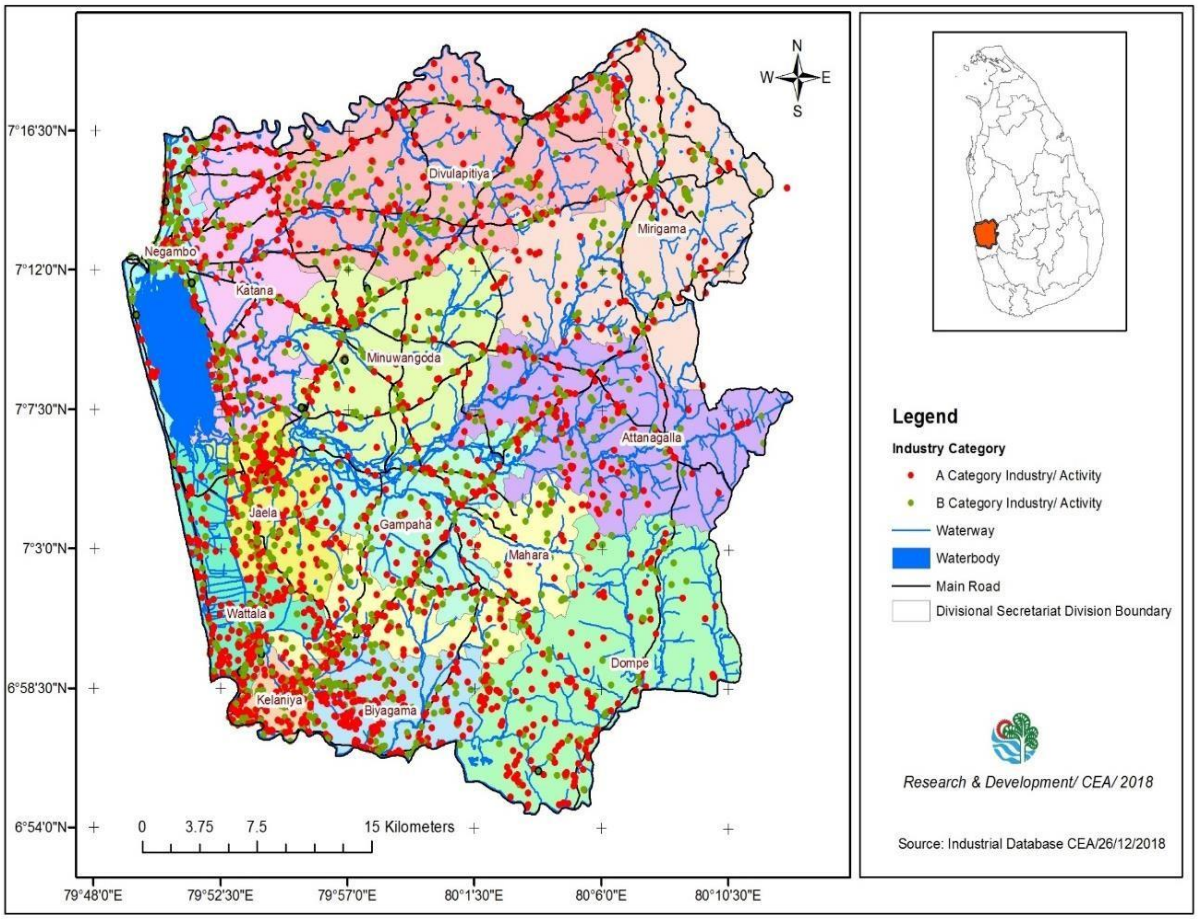
Prescribed Industries/ Activities in Gampaha District



Source: Research and Development Department, Environmental Authority

Appendix 3

Prescribed Industries/ Activities (A&B category) in Gampaha District



Source: Research and Development Department, Environmental Authority