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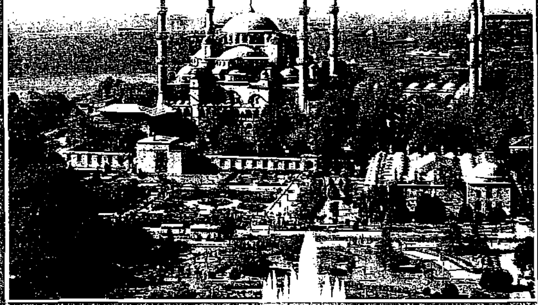

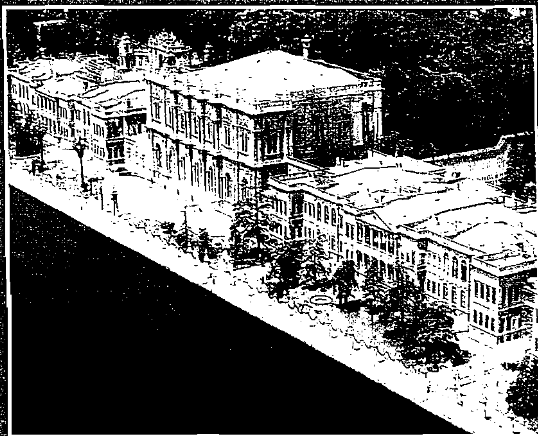

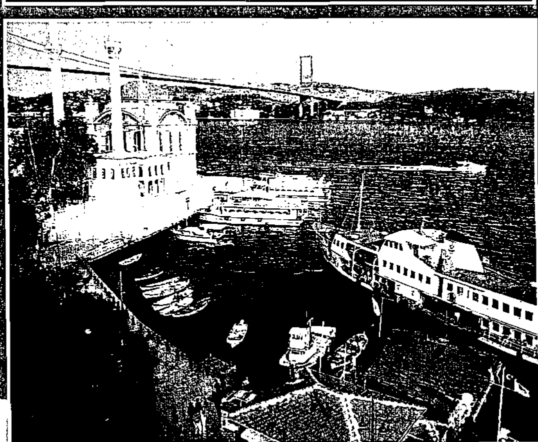

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LOGISTICS CHAIN ANALYSIS: A BASIS FOR ASSESSING GREENHOUSE IMPACTS OF TRANSPORT ACTIVITIES FOR INDUSTRIAL PERMISES

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Abstract

The main production and warehousing premises of Egypt Eastern Company for Tobacco (EECT)∗ is currently located in four different locations in Giza, Greater Cairo. The company is planning to agglomerate and relocate all of its premises into one big location in the industrial area of 6th of October new City to the south-west of Cairo. This research is concerned with assessing and comparing the greenhouse environmental impacts, resulting from transport activities in the two alternative location scenarios. In this context, two logistics chains that simulate activities and flow of raw materials and products for the company are developed. The first represents the company activities and operation from its current locations, while the second represents the expected operation of the company from its planned new location in 6th of October City. Transport phases in both chains are uniquely identified and described. A literature survey is conducted to obtain appropriate emission factors of the six main greenhouse gases emitted by transport activities. For each of the two considered industrial location scenarios, transport activities, represented by annual number of travelled kilometers, are multiplied by appropriate emission factors and expected annual values of six types of emissions are obtained. Finally, a comparative analysis is conducted to determine the location scenario expected to produce the least greenhouse emissions as a result of its transport activities.

Keywords: Relocation; Industries; Logistics chain; Transport activities; Greenhouse impacts
Topic Area: B3 Logistics, Freight and Fleet Management

1. Introduction

Since mid seventies, the Egyptian government has embarked on a spatial planning policy based on attracting development into the desert areas away from the Nile and the main cities of the Delta. Some of the new developments, notably Tenth of Ramadan, Sadat and Six of October cities, are developed as productive societies to stand in a relatively independent fashion away from the Delta and Nile valley.

The main production and warehousing premises of EECT is currently located in four different locations in Giza, Greater Cairo. The company is planning to agglomerate and relocate all of its premises into one big location in the industrial area of 6th of October new City to the south-west of Cairo. This research is concerned with assessing and comparing the greenhouse environmental impacts, resulting from transport activities in two scenarios. The first scenario is that of EECT continuing to operate from more than one premise, all, located in an urban area dominated by residential land use in Greater Cairo. On the other hand, the second scenario is concerned with the agglomeration and relocation of these industrial premises into the industrial area located in 6th of October new city in the western Egyptian desert. Such objective falls in line

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∗ The author strongly acknowledges his discouragement of smoking. The research in this paper is not meant in any context to encourage or promote smoking or the business of tobacco production.

with the viewpoints stated by Owens (1995), i.e. looking at the interactions between land use, transport and climate change. In this context, two research studies that looked at relocation decisions were identified. The first examined the effect of office relocation in Oslo on employees travel behaviour, see Hanssen (1995). This study did not consider any environmental effects resulting of relocation decisions. The other research reported by Aarhus (2000) examined the ineffectiveness of office location decisions in Norway in terms of increasing instead of reducing commuting trips and hence becoming a potential for environmental degradation instead of improvement.

To achieve the above stated objective, this research follows a unique line of analysis, where two logistics chains that simulate activities and flow of raw materials and products for the company are developed. The first chain represents the company activities and operation from its current locations, while the second represents the expected operation of the company from its planned new location in 6th of October City. Activities considered in the developed logistics chains include procurement, transport of raw materials, storage, production, transport of products to warehouses, and distribution of products to customers. These chains describe the process involved in such business and provide insightful details and information.

Transport phases in both chains are uniquely identified and described. Such description involves stating the type of transported cargo, trip origins and destinations, as well as the type of fleet being utilised. Relevant operation data are then collected from field surveys, site visits, interviews and inspection of transport records. These are compiled to synthesise travelled distances, number of daily trips, average speeds for each of the unique transport phases as well as for each trip type. This is then followed by quantitatively representing transport activities through computing annual number of travelled kilometers.

A literature survey is also conducted in an effort to obtain appropriate emission factors of the six main greenhouse gases emitted by transport activities; namely carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_X), nitrous oxide (N_2O), methane (CH_4), and non-methane volatile organic compounds (NMVOC). Different emission rates are considered based on vehicle type, type of fuel, as well as on type of vehicle emission control (if any). Furthermore, these rates are multiplied by appropriate adjustment factors to reflect differences in operating conditions represented by average travelling speed. For each of the two considered industrial location scenarios, transport activities, represented by annual number of travelled kilometers, are multiplied by appropriate emission factors and expected annual values of the six types of emissions are obtained for both scenarios. Finally, a comparative analysis is conducted to determine the industrial location scenario expected to produce the least greenhouse emissions as a result of its transport activities.

The above comparative analysis revealed that the new planned location is expected to increase the amount of emissions. The reasons for such increases can be mainly attributed to the increase in transport activities in terms of average trip distance and hence annual travelled kilometers. This is expected for trips concerned with distribution of final products to customers and company's branches as well as for the typical daily work trips for the labour force commuting mostly from Cairo neighborhoods to 6th of October city.

2. Logistics chains for EECT: A basis for identifying transport phases

The main production and warehousing premises of EECT is currently located in four separate locations in Giza, Greater Cairo. These locations include the main production center, Al Talbia production and waste disposal center, Zomer warehouses and filter and printing production premise, and the warehouses for raw tobacco. All four premises are within highly populated residential areas located in the southwest of Greater Cairo, see figure 1. The figure shows that Greater Cairo is circled by the ring road, which intersects with all rural roads connecting Cairo to the rest of Egypt. EECT is planning to agglomerate and relocate all of its premises into one big location in the industrial area of 6th of October new City, see figure 1. This is one of the first three cities that the Egyptian government has designated as a stand alone productive city in the Egyptian west desert and away from the Delta and Nile valley.

In this section, two logistics chains are constructed. These are meant to simulate activities and flow of raw materials and products for the company. The first chain represents the company activities and operation from its current locations, while the second represents the expected operation of the company from its planned new location in 6th of October City. The purpose of developing these chains is to assist in uniquely identifying and describing the main transport phases operated by the company's transport fleet, or by fleets owned/rented by suppliers or customers. In this research, the concept of green logistics is introduced, see Rodrigue et al. (2001), where the chain causing the least greenhouse gaseous emissions from its transport activities will be identified.

The first chain represents the company activities and operation from its current locations in Giza. As shown in figure 2, nine main stages can be identified, namely:

a) Purchase of foreign raw tobacco and supplies necessary for production.
b) Transport of raw tobacco from Alexandria port, using Alexandria-Cairo desert road and passing 6th of October entrance, to the warehouses designated for raw tobacco and customs clearance. This stage also involves the transportation of production requirements from their sources to Zomer warehouses.
c) Storage of raw tobacco and production supplies as well as conducting customs clearance for imported raw tobacco.
d) Production of filter and printing in Zomer production plant.
e) Transport of raw tobacco, production supplies and filter and printing to the main production center as well as to Al Talbia production plant.
f) Storage of raw tobacco and supplies to be directly available for production process.
g) Production of tobacco and cigarettes and transport of production waste to Al Talbia waste collection and disposal center.
h) Storage of finished products, i.e. tobacco and cigarettes.
i) Marketing and transport of finished products to wholesale and retail customers as well as to company's branches across Egypt. Also this stage involves the transport of production waste to waste customers or to disposal areas in the desert.

The first sixth stages can be grouped under the inbound logistics component of the chain. The seventh stage is the core of the process where cigarettes and tobacco are produced. Stages eight and nine represent the outbound logistics component of the chain.

The second chain represents the company activities and operation from its planned new location in 6th of October new city, where all company premises will be agglomerated together. As shown in figure 3, seven main stages can be identified. These are similar to the ones considered in the first chain i.e. procurement, transport, storage and customs clearance of raw tobacco, followed by production of cigarettes and tobacco, collection of production waste, as well as storage, transport and distribution of cigarettes and tobacco to customers and company's branches located across Egypt.

Unique transport phases in both chains are identified and described, see table 1. The table shows that through agglomeration of premises in one location, the two short distance transport phases are not warranted any more. It is also worth noting, at this point, that for the other transport phases, the extent of transport activities, measured in travelled kilometers, is expected to differ with respect to each location scenario.

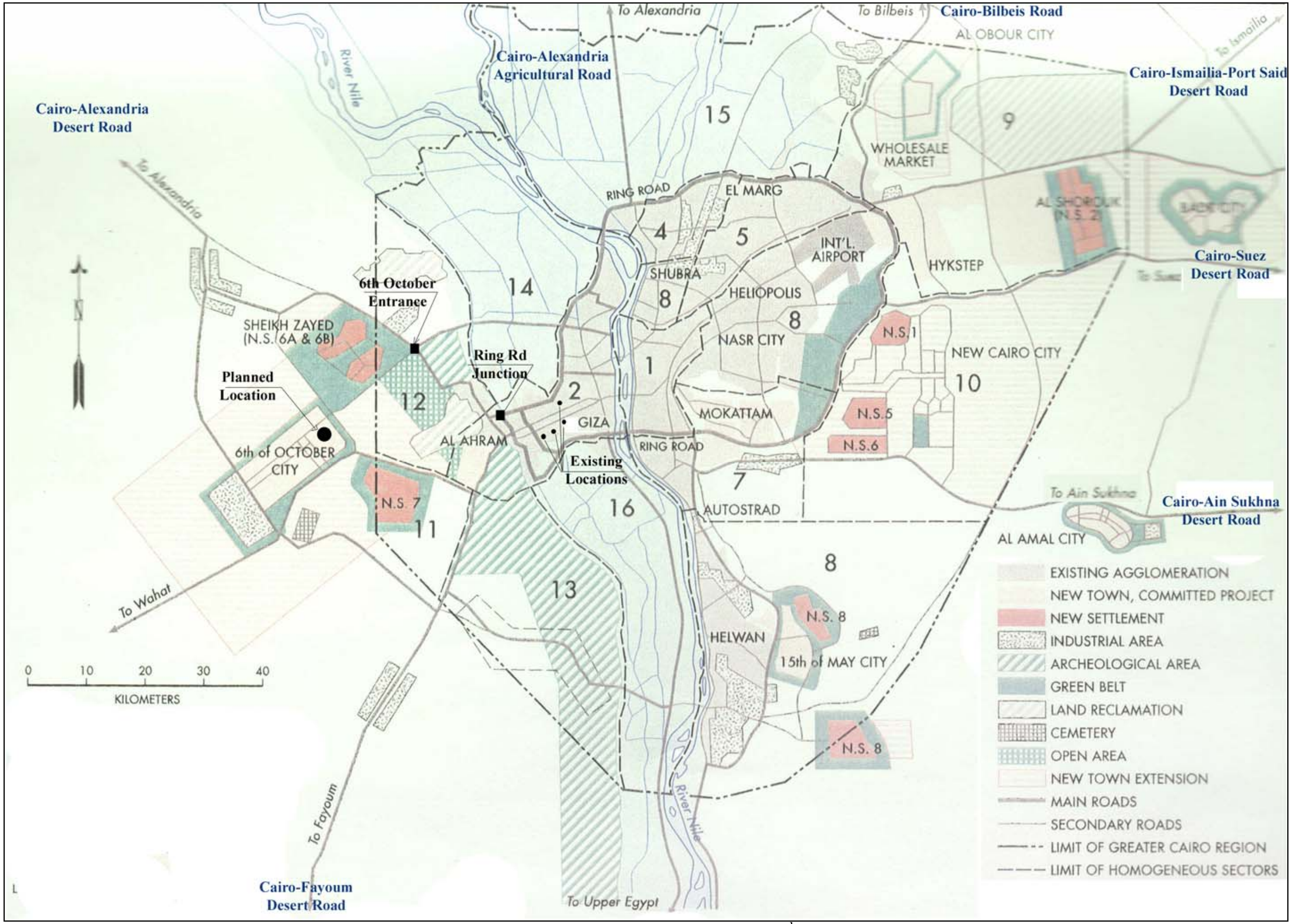

Figure 1: Existing 4 Locations of EETC in Giza (Greater Cairo) & Planned New Location in 6th of October New City (Map Adapted from World Bank, 2000)

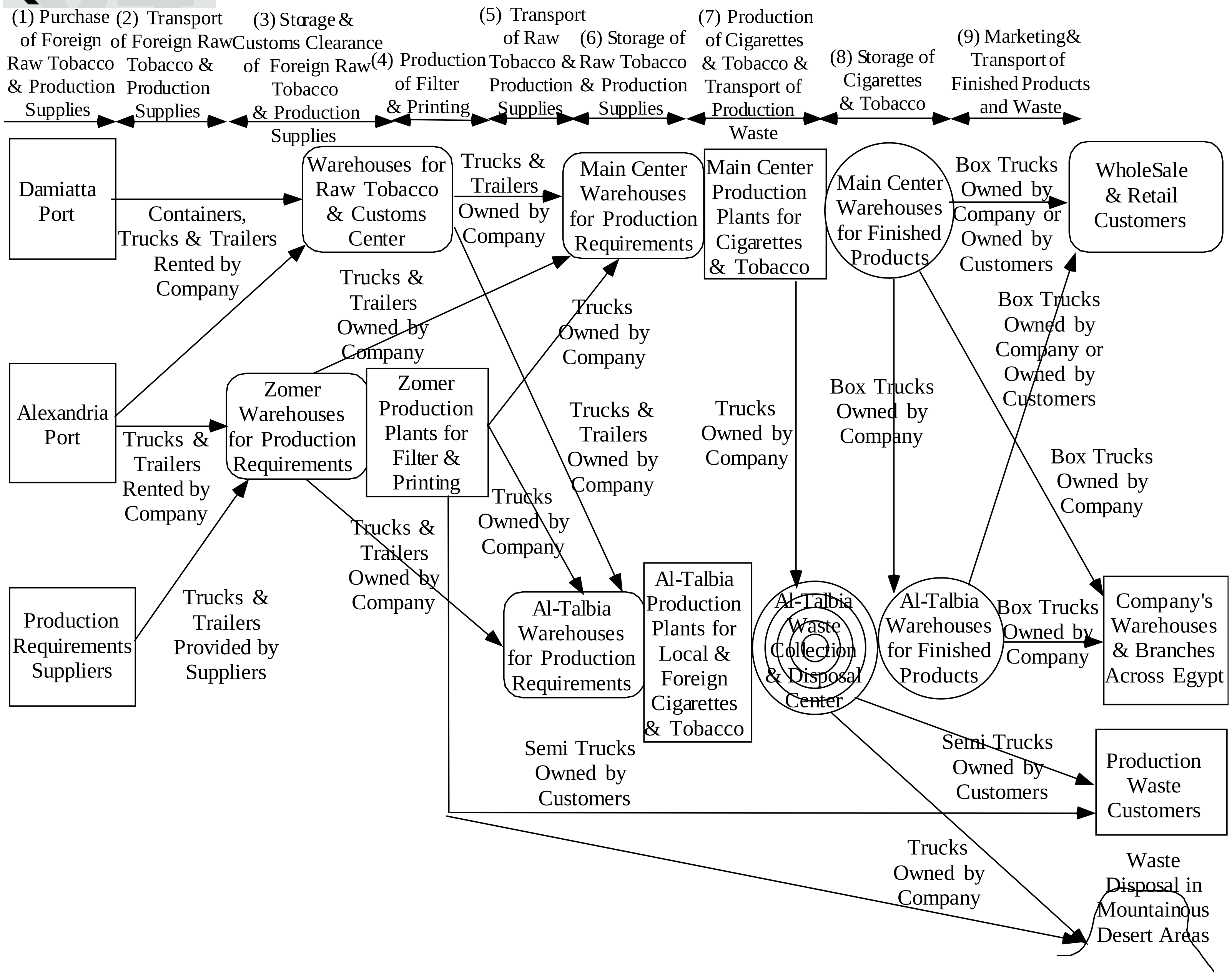

Figure 2: Logistics Chain of Activities Involved in Operating EECT from its Current 4 Locations in Giza

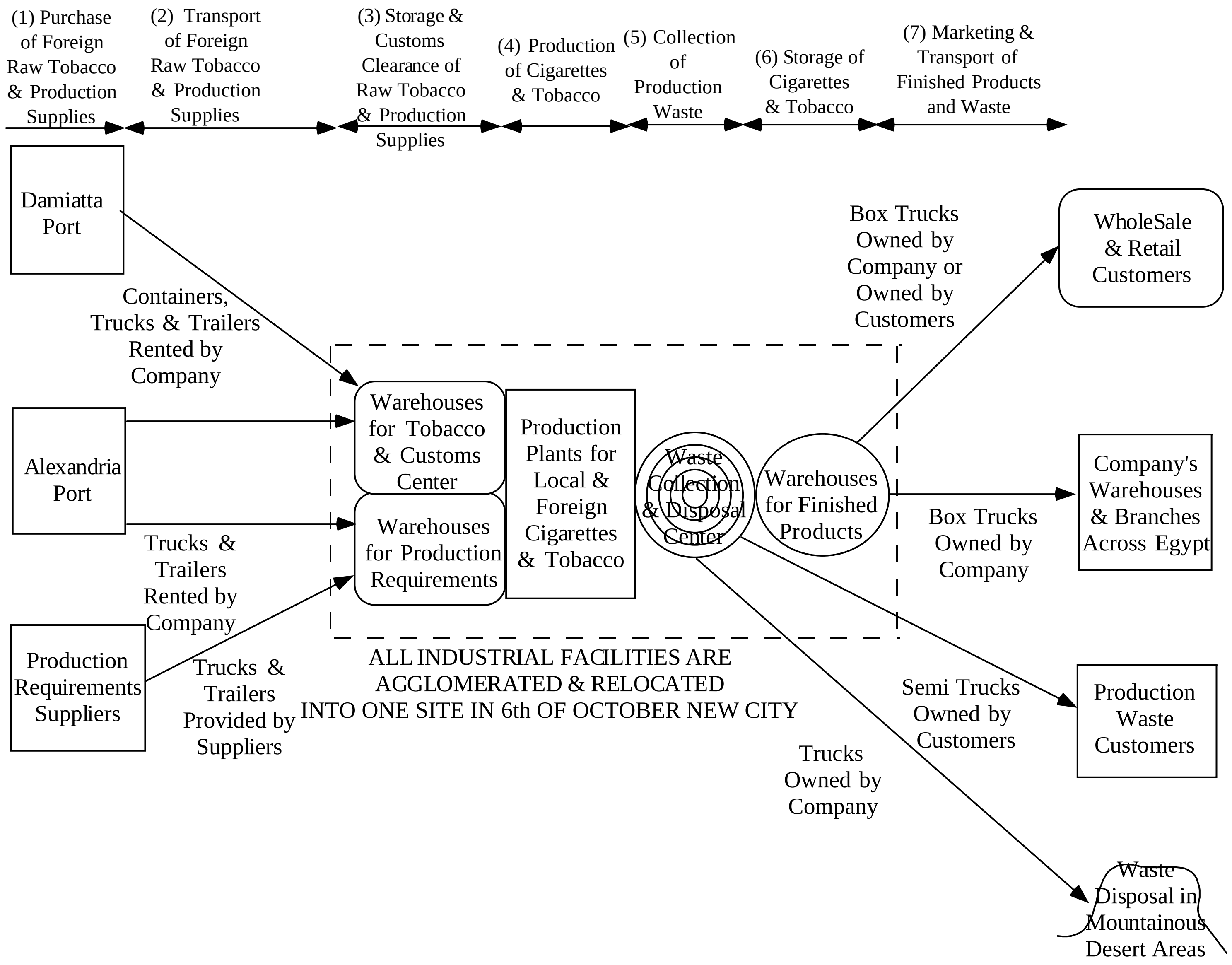

Figure 3: Logistics Chain of Activities Involved in Future Operation of EECT from its Planned Location in 6th of October New City

Table 1: Unique Transport Phases Identified in EECT Location Scenarios

Current EECT Locations Including Four Premises in Giza, Greater Cairo	Planned Agglomeration & Relocation into One New Premise in 6th of October New City
(1) Long Distance Transport of Raw Materials	(1) Long Distance Transport of Raw Materials
(2) Short Distance Transport of Raw Materials from Warehouses to Production Sites	None as a Result of Agglomeration
(3) Short Distance Transport of Filter/Printing	None as a Result of Agglomeration
(4) Medium Distance Transport of Final Products to Customers & Distribution Centers	(2) Long Distance Transport of Final Products to Customers & Distribution Centers
(5) Short/Medium Distance Transport of Production Waste	(3) Medium/Long Distance Transport of Production Waste
(6) Medium Distance for Transport of Employees to Company Sites	(4) Long Distance for Transport of Employees to Company Sites

3. Green house emissions resulting of transport activities

This research is concerned with assessing and comparing the greenhouse emissions, resulting from transport activities in the two considered industrial location scenarios. The algorithm used for such computation is depicted in figure 4. It constitutes several steps that are followed in an effort to estimate two basic parameters namely annual transport activities and appropriate emission rates. In the following sub-sections, details of the procedure are shown. The following represents the mathematical formulation used to compute the annual greenhouse emissions expected from transport activities.

Annual Emissions = Annual Transport Activities * Emission Rate

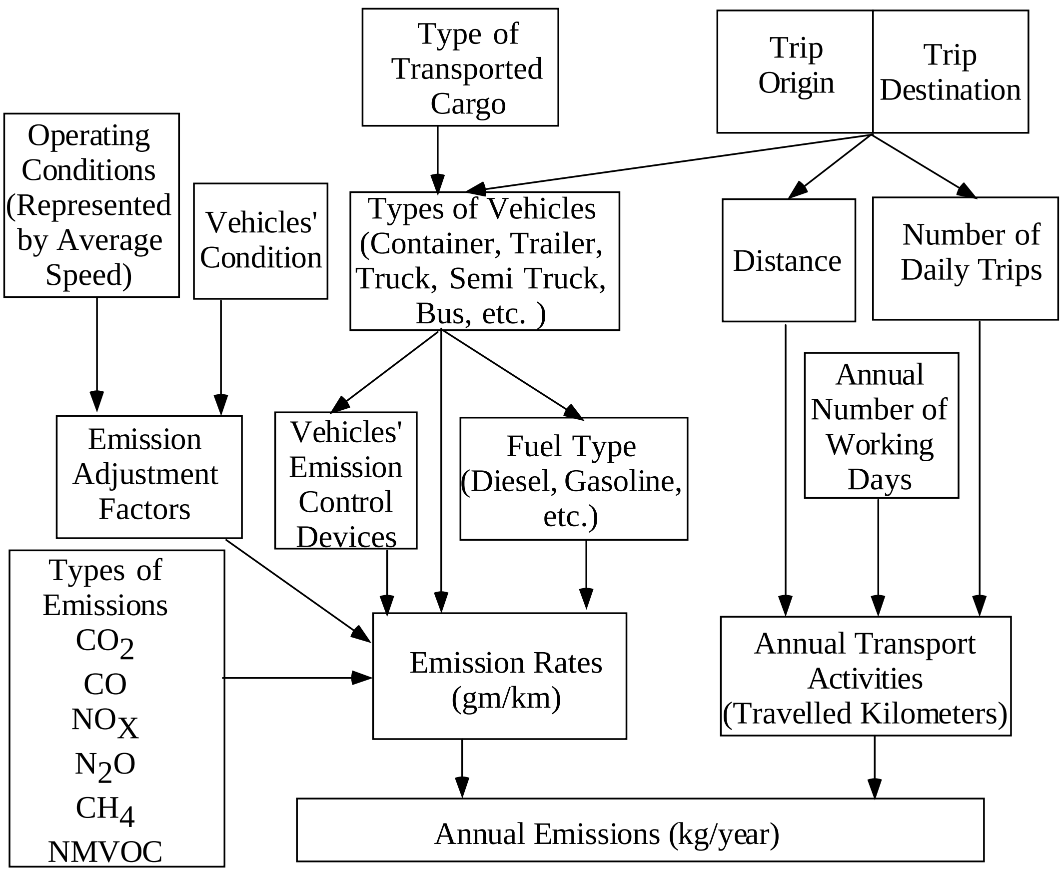

Figure 4: Procedure for Estimation of Annual Emissions Resulting from Transport Activities

3.1. Estimation of annual transport activities

As shown in table 2, transport activities were estimated for current and planned EECT locations. Such estimates are based on distances of typical trips as well as on number of daily trips. In this context, the two logistics chains were examined where for each unique transport phase, trip origins, destinations, and type of transported cargo were identified, see table 2. This was followed by conducting floating vehicle surveys, where distances and average speeds were determined for each trip. Interviews with transport operators within EECT and examination of transport record books revealed the type of fleet as well as the average number of daily trips between each origin and destination. Based on this collected and synthesised information, annual transport activities for each trip type was determined, see table 2. Mathematical formulation used to compute annual transport activities took the following form.

$$\text{Annual Transport Activities}_{ij} = \text{Distance}_{ij} * \text{Daily Trips}_{ij} * \text{Annual Working Days (AWD)}$$

Where: i = Trip Origin j = Trip destination

Values in table 2 demonstrate that transport activities related to movement of the company's work force is the most dominant with a percentage contribution of 44% in the current case and an expected contribution of 65% in case of planned new location in 6^{th} of October city. This is mainly due to the residing of most of the work force in Cairo neighborhoods, where in the case of the new location, the average distance of a work trip would dramatically increase from currently being on average 10 kilometers to become around 65 kilometers in case of the new planned location. Additionally, the table shows that raw material trips originating from Alexandria port become relatively shorter in case of planned new location as 6^{th} of October city is nearer to Alexandria-Cairo desert road than the existing EECT locations. It is also obvious from the table that those short distance trips between the current EECT four premises do not contribute to more than 1.7% of total transport activities.

3.2. Determination of appropriate emission rates

A literature review was conducted in an effort to determine the types of gaseous emissions to be taken into account as well as the appropriate emission rates and factors to be considered in the determination of such rates, see Faiz et al. (1990), Weaver et al. (1994), Faiz et al. (1996) and IPCC (1996). Six main exhaust emissions; namely CO_2, CO resulting of incomplete combustion, NO_X resulting of high temperature from combustion, N_2O, CH_4, NMVOC; are considered, see figure 4. These are known as greenhouse gases. As shown in table 3, emission factors for the six main gaseous emissions resulting from transport activities were determined from the Intergovernmental Panel on Climate Change (IPCC) reference manual. The IPCC was established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP). The IPCC guidelines for national greenhouse gas inventories are internationally developed and approved. The emission factors elicited from the IPCC manual were selected based on the consideration of vehicle type, type of fuel, as well as type of vehicle emission control (if any). Furthermore, these factors were multiplied by appropriate adjustment factors to reflect differences in operating conditions represented by average travelling speed. Recent studies have utilised IPCC rates for computation of greenhouse gases in developing countries, see El-Fadel & Bou-Zeid (1999). The mathematical formulation used to compute emission rates took the following form.

$$\text{Emission Rate}^{E} = \text{Emission Factor}^{E}{}_{VFC} * \text{Emission Adjustment Factor}_{S}$$

Where: E = Emission Type, V = Vehicle Type, F = Fuel Type, C = Emission Control Type
S = Average Speed Representing Operating Conditions

3.3. Computation of annual emissions

For each of the two considered industrial location scenarios, transport activities for each trip type were multiplied by appropriate emission factors and expected annual values of the six types of emissions were obtained, see table 4. The mathematical formulation used to compute annual emissions for each trip type took the following form.

$$\text{Annual Emissions}^{E}{}_{ij} = \text{Annual Transport Activities}_{ij} * \text{Emission Rate}^{E}$$

Table 2: Detailed Estimation & Comparison of Annual Transport Activities for Current Location of EECT Versus Planned New Location

Description of Unique Transport Phases	Origins (i)	Destinations (j)	Transported Cargo	Distance in Km.	Type of Fleet	Average Daily Trips	Annual Transport Activities**	% of Annual Transport Activities
Long Distance Transport of Raw Materials	Alexandria Port Using Alex.-Cairo Desert Road (i.e. from 6th October Entrance)*	Zomer Warehouses (Planned New Location)	Production Requirements	30 (25)***	Trailers	20	180000 km (150000)	
	Alexandria Port Using Alex.-Cairo Desert Road (i.e. from 6th October Entrance)*	Warehouses for Raw Tobacco (Planned New Location)	Raw Tobacco	30 (25)	Containers	10	90000 (75000)	26.4% (5%)
Short Distance Transport of Raw Materials from Warehouses	Zomer Warehouses	Main Center Warehouses	Production Requirements	1.5	Trailers	7	3150	
	Zomer Warehouses	Al-Talbia Warehouses		2.5	Trucks	4	3000	
	Warehouses for Raw Tobacco	Main Center Warehouses	Raw Tobacco	1.5	Trailers	6	2700	1.1%
	Warehouses for Raw Tobacco	Al-Talbia Warehouses	Raw Tobacco	2.5	Trailers	3	2250	(None)
Short Distance Filter Transport	Zomer Production Plant	Main Center Warehouses	Filter/Printing	1.5	Trailers	7	3150	0.6%
	Zomer Production Plant	Al-Talbia Warehouses	Filter/Printing	2.5	Trucks	4	3000	(None)
Medium/Long Distance Transport of Final Products to Customers & Distribution Centers	Main Center Final Product Warehouses	Al-Talbia Final Product Warehouses	Final Products	4 (None)	Boxed Trucks	3 (None)	3600 (None)	
	Main Center Final Product Warehouses (Planned New Location)	Customers & Distribution Centers (i.e. to Ring Road*)	Final Products	10 (45)	Boxed Trucks	30	90000 (405000)	
	Main Center Final Product Warehouses (Planned New Location)	Customers & Distribution Centers in Cairo	Final Products	10 (65)	Boxed Trucks	10	30000 (195000)	
	Al-Talbia Final Product Warehouses (Planned New Location)	Customers & Distribution Centers (i.e. to Ring Road*)	Final Products	8.5 (45)	Boxed Trucks	10	25500 (135000)	
	Al-Talbia Final Product Warehouses (Planned New Location)	Customers & Distribution Centers in Cairo	Final Products	14 (65)	Boxed Trucks	20	84000 (390000)	22.8% (25.1%)
Short/Long Distance Transport of Production Waste	Main Center Production Plant	Al-Talbia Waste Collection & Disposal Center	Production Waste	4 (None)	Trucks	4 (None)	4800 (None)	
	Al-Talbia Waste Collection & Disposal Center (Planned New Location)	Waste Customers	Production Waste	10 (60)	Semi-Trucks	6	18000 (108000)	
	Al-Talbia Waste Collection & Disposal Center (Planned New Location)	Mountain	Production Waste	15 (5)	Trucks	2	9000 (3000)	
	Zomer Production Plant (Planned New Location)	Waste Customers	Production Waste	10 (60)	Semi-Trucks	4	12000 (72000)	
	Zomer Production Plant (Planned New Location)	Mountain	Production Waste	15 (5)	Trucks	1	4500 (1500)	4.7% (4.1%)
Transport of Employees to Company Sites	Cairo	Company Sites (Planned New Location)	Work Force	10 (65)	Company Bus/Mini	26	78000 (507000)	
	Cairo	Company Sites (Planned New Location)	Work Force	10 (65)	Bus/Mini/ Micro	125	375000 (2437500)	44.3% (65.7%)

(*) Common Distances are Ignored (**) Annual Working Days is 300 days (***) Origins, Destinations, Distances, & Transport Activities are in Brackets for Planned New Location

Table 3: Determination of Appropriate Emission Factors for Transport Activities for Current Location of EECT as well as for Planned New Location

Origins	Destinations	Type of Fleet	Type of Fuel	Emission Control	Average Speed km/hr.	Emission Adjust. Factor	CO_2 Factor (*)	CO Factor (*)	NO_X Factor (*)	N_2O Factor (*)	CH_4 Factor (*)	NO_X Factor (*)
Alexandria Port Passing 6th October Entrance	Zomer Warehouses	Trailers	Diesel	None	40 (60)**	1.5 (1.3)	1097	4.85	10.3	0.031	0.06	1.63
Alexandria Port Passing 6th October Entrance	Warehouses for Raw Tobacco	Containers	Diesel	None	40 (60)	1.5 (1.3)	1097	4.85	10.3	0.031	0.06	1.63
Zomer Warehouses	Main Center Warehouses	Trailers	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Zomer Warehouses	Al-Talbia Warehouses	Trucks	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Warehouses for Tobacco	Main Center Warehouses	Trailers	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Warehouses for Tobacco	Al-Talbia Warehouses	Trailers	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Zomer Production Plant	Main Center Warehouses	Trailers	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Zomer Production Plant	Al-Talbia Warehouses	Trucks	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Main Center Final Product Warehouses	Al-Talbia Final Product Warehouses	Boxed Trucks	Diesel	None	25	1.7	415	1.01	0.92	0.031	0.01	0.49
Main Center Final Product Warehouses	Customers & Distribution Centers Passing Ring Road	Boxed Trucks	Diesel	None	40 (60)	1.5 (1.3)	415	1.01	0.92	0.031	0.01	0.49
Main Center Final Product Warehouses	Customers & Distribution Centers in Cairo	Boxed Trucks	Diesel	None	20 (50)	1.8 (1.4)	415	1.01	0.92	0.031	0.01	0.49
Al-Talbia Final Product Warehouses	Customers & Distribution Centers Passing Ring Road	Boxed Trucks	Diesel	None	40 (60)	1.5 (1.3)	415	1.01	0.92	0.031	0.01	0.49
Al-Talbia Final Product Warehouses	Customers & Distribution Centers in Cairo	Boxed Trucks	Diesel	None	20 (50)	1.8 (1.4)	415	1.01	0.92	0.031	0.01	0.49
Main center Production Plant	Al-Talbia Waste Collection & Disposal Center	Trucks	Diesel	None	25	1.7	1097	4.85	10.3	0.031	0.06	1.63
Al-Talbia Waste Collection & Disposal Center	Waste Customers	Semi-Trucks	Diesel	None	20 (50)	1.8 (1.4)	415	1.01	0.92	0.031	0.01	0.49
Al-Talbia Waste Collection & Disposal Center	Mountain	Trucks	Diesel	None	30 (60)	1.7 (1.3)	1097	4.85	10.3	0.031	0.06	1.63
Zomer Production Plant	Waste Customers	Semi-Trucks	Diesel	None	20 (50)	1.8 (1.4)	415	1.01	0.92	0.031	0.01	0.49
Zomer Production Plant	Mountain	Trucks	Diesel	None	30 (60)	1.7 (1.3)	1097	4.85	10.3	0.031	0.06	1.63
Cairo	Company Sites	Company Bus/Mini	Diesel	None	20 (40)	1.8 (1.5)	415	1.01	0.92	0.031	0.01	0.49
Cairo	Company Sites	Bus/Mini/ Micro	Gasoline	None	20 (40)	1.8 (1.5)	270	46	2.2	0.005	0.07	5.3

(*) Emission factors in gm/km are extracted from IPCC (1996) (**) For Comparison, Speeds and Emission Adjustment Factors are Given in Brackets for Planned New Location

Table 4: Estimation & Comparison of Annual Emissions Resulting from Transport Activities for Current Location of EECT Versus Planned New Location

Origins	Destinations	CO_2 Emissions	CO Emissions	NO_X Emissions	N_2O Emissions	CH_4 Emissions	NMVOC Emissions
Alexandria Port Passing 6th October Entrance	Zomer Warehouses (Planned New Location)	296190.0 (213915)	1309.5 (945.8)	2781.0 (2008.5)	8.4 (6)	16.2 (11.7)	440.1 (317.9)
Alexandria Port Passing 6th October Entrance	Warehouses for Raw Tobacco (Planned New Location)	148095.0 (106957)	654.8 (472.9)	1390.5 (1004.3)	4.2 (3)	8.1 (5.9)	220 (158.9)
Zomer Warehouses	Main Center Warehouses	5874.4	26.0	55.2	0.2	0.3	8.7
Zomer Warehouses	Al-Talbia Warehouses	5594.7	24.7	52.5	0.2	0.3	8.3
Warehouses for Raw Tobacco	Main Center Warehouses	5035.2	22.3	47.3	0.1	0.3	7.5
Warehouses for Raw Tobacco	Al-Talbia Warehouses	4196.0	18.6	39.4	0.1	0.2	6.2
Zomer Production Plant	Main Center Warehouses	5874.4	26.0	55.2	0.2	0.3	8.7
Zomer Production Plant	Al-Talbia Warehouses	5594.7	24.7	52.5	0.2	0.3	8.3
Main Center Final Product Warehouses	Al-Talbia Final Product Warehouses	2539.8 (None)	6.2 (None)	5.6 (None)	0.2 (None)	0.1 (None)	3.0 (None)
Main Center Final Product Warehouses (Planned New Location)	Customers & Distribution Centers Passing Ring Road	56025.0 (218498)	136.4 (532)	124.2 (484)	4.2 (16)	1.4 (5)	66.2 (258)
Main Center Final Product Warehouses (Planned New Location)	Customers & Distribution Centers in Cairo	22410.0 (113295)	54.5 (275.73)	49.7 (251.1)	1.7 (8.5)	0.5 (2.7)	26.5 (133.7)
Al-Talbia Final Product Warehouses (Planned New Location)	Customers & Distribution Centers Passing Ring Road	15873.8 (72833)	38.6 (177)	35.2 (161)	1.2 (5)	0.4 (2)	18.7 (86)
Al-Talbia Final Product Warehouses (Planned New Location)	Customers & Distribution Centers in Cairo	62748.0 (226590)	152.7 (551.5)	139.1 (502.3)	4.7 (16.9)	1.5 (5.5)	74.1 (267.5)
Main Center Production Plant	Al-Talbia Waste Collection & Disposal Center	8951.5 (None)	39.6 (None)	84.0 (None)	0.3 (None)	0.5 (None)	13.3 (None)
Al-Talbia Waste Collection & Disposal Center (Planned New Location)	Waste Customers	13446.0 (62748)	32.7 (152.7)	29.8 (139.1)	1.0 (4.7)	0.3 (1.5)	15.9 (74)
Al-Talbia Waste Collection & Disposal Center (Planned New Location)	Mountain	16784.1 (4278)	74.2 (18.91)	157.6 (40.17)	0.5 (0.1)	0.9 (0.23)	24.9 (6.4)
Zomer Production Plant (Planned New Location)	Waste Customers	8964.0 (41832)	21.8 (101.8)	19.9 (92.7)	0.7 (3.1)	0.2 (1)	10.6 (49)
Zomer Production Plant (Planned New Location)	Mountain	8392.1 (2139)	37.1 (9.5)	78.8 (20.1)	0.2 (0.1)	0.5 (0.1)	12.5 (3.2)
Cairo	Company Sites (Planned New Location)	58266.0 (315607)	141.8 (768.1)	129.2 (699.7)	4.4 (23.6)	1.4 (7.6)	68.8 (372.6)
Cairo	Company Sites (Planned New Location)	182250.0 (987187)	31050 (168187)	14850 (8043.8)	3.4 (18.3)	47.3 (256)	3578 (19378)

(*) For Comparison, Origins, Destinations and Emission Values in Kg/Year are Given in Brackets for Planned New Location

4. Comparative assessment of annual emissions resulting from transport activities of the two EECT location scenarios

A comparative analysis was conducted to determine the industrial location scenario expected to produce the least greenhouse emissions as a result of its transport activities. Such comparison is depicted in table 5. The table clearly shows that transport activities represent a significant source of CO_2 emissions, followed by CO, NO_X, NMVOC, CH_4 and finally N_2O. Most importantly, the table demonstrates that the new planned location is expected to increase the amount of emissions by almost 1.5 times for CO_2, 4 times for CO, 1 time for NO_X, 2 times for N_2O, 2.7 times for CH_4 and 3.5 times for NMVOC. The reasons for such dramatic increases can be mainly attributed to the increase in transport activities in terms of average trip distance and hence annual travelled kilometers. This is expected to occur mostly as a result of trips concerned with distribution of final products to customers and company's branches as well as of the typical daily work trips for the labour force. Labour force is expected to commute mostly from Cairo neighborhoods to 6th of October city, hence increasing their average trip distance by approximately 55 kilometers.

Table 5: Comparison of Annual Emissions Resulting from Transport Activities for Current Location of EECT Versus Planned New Location

Transport Activities	Company Locations	CO_2 Emissions	CO Emissions	NO_X Emissions	N_2O Emissions	CH_4 Emissions	NMVOC Emissions
Long Distance Transport of Raw Materials	Current Locations	444285 47.6%	1964 5.8%	4171 61.2%	12.6 35.1%	24.3 30.0%	660 14.3%
	Planned Location	320872 13.6%	1418.6 0.8	3012.8 22.4%	9.1 8.5%	17.6 5.9%	476.8 2.3%
Short Distance Transport of Raw Materials from Warehouses to Production Sites	Current Locations	20700 2.2%	91.5 0.3%	194 2.9%	0.6 1.6%	1.1 1.4%	30.8 0.7%
	Planned Location	None	None	None	None	None	None
Short Distance Transport of Filter/Printing	Current Locations	11469 1.2%	50.7 0.1%	107 1.6%	0.3 0.9%	0.6 0.8%	17.0 0.4%
	Planned Location	None	None	None	None	None	None
Medium/Long Distance Transport of Final Products to Customers & Distribution Centers	Current Locations	159596 17.1%	388.4 1.1%	353 5.2%	11.9 33.3%	3.8 4.7%	188.4 4.1%
	Planned Location	631215 26.7%	1536.2 0.9%	1399.3 10.4%	47.2 44.5%	15.2 5.1%	745.3 3.5%
Short/Long Distance Transport of Production Waste	Current Locations	56537 6.1%	205.4 0.6%	370 5.4%	2.6 7.4%	2.4 3.0%	77.2 1.7%
	Planned Location	110997 4.7%	283 0.2%	292.1 2.2%	8.0 7.5%	2.9 1%	133.0 0.6%
Medium/Long Distance Transport of Employees to Company Sites	Current Locations	240516 25.8%	31191 92%	1614 23.7%	7.7 21.6%	48.7 60.1%	3646 78.9%
	Planned Location	1302795 55.1%	168955 98.1%	8743.4 65%	41.9 39.5%	263.5 88.1%	19750 93.6%
Total	Current Locations	933104 100%	33892 100%	6811 100%	35.8 100%	81 100%	4620 100%
	Planned Location	2365880 100%	172193 100%	13447 100%	106.1 100%	299 100%	21106 100%
Planned – Current	Difference	1432776	138301	6636	70.3	218	16486

5. Conclusions

This research was mainly concerned with assessing expected differences in transport related greenhouse emissions resulting of an industrial enterprise, namely EECT intending to agglomerate its industrial premises and move from an urban residentially dominated setting (i.e. Giza in Greater Cairo) to relocate into a new industrial area (i.e. 6th of October new city). In this context, a unique methodology was followed, where two logistics chains were developed to describe company's activities in existing locations versus its expected activities in planned new location. These chains were used as the basis for identifying details needed to compute the annual transport activities conducted by the company in both situations. Through these chains, unique transport phases were identified, origins, destinations, trip distances, type of cargo, and type of fleet all were determined. This was complemented by conducting vehicle-floating surveys to determine typical average speed of these trips. Additionally, several interviews and inspection of transport records revealed the average number of daily trips for each unique transport phase.

The research went on to examine the literature in an effort to obtain appropriate greenhouse emission factors. Such factors were elicited from the literature taking into consideration elements such as vehicle type, type of fuel and emission control. These factors were further adjusted taking into account operating conditions represented by average speed. Finally, annual emissions were computed based on the multiplication of annual transport activities by appropriate emission rates.

A comparative analysis was then conducted to determine the industrial location scenario expected to produce the least greenhouse emissions as a result of its transport activities. Such comparison revealed that the new planned location is expected to dramatically increase the amount of emissions. This can be mainly attributed to the increase in transport activities in terms of average trip distance and hence annual travelled kilometers for trips concerned with distribution of final products to customers and company's branches as well as for the typical daily work trips for the labour force commuting mostly from Cairo neighborhoods to 6^{th} of October city.

Based on these results, one might conclude that, in relative terms, the green logistics chain is the one where the company continues to operate from its current 4 premises in Giza. However, such conclusion cannot be taken in isolation, as most of the emissions from transport activities of the planned new location are expected to occur and disperse mostly in desert areas with minimum effects on human settlements or water resources. On the other hand, almost all emissions resulting of existing location, occur and disperse within highly populated residential areas, thus expected to contribute to health hazards and water pollution. This notion is known as emission exposure, see USEPA (1999). Exposure to emissions is definitely much higher in case company continues its operation from its current locations. In addition, if the company was to support its relocation decision with another decision of offering its work force housing within 6^{th} of October new city, this would dramatically reduce the amount of expected emissions. In this case, emissions would be confined to supply trips of tobacco and raw materials as well as to distribution trips of final products. Alternatively, the company can provide its work force with high capacity buses that preferably run with compressed natural gas (CNG) in an effort to reduce the number of mini/microbus trips as well as to provide an environmentally cleaner mode of transport.

In conclusion, it has to be also noted that this research tackled, only, the greenhouse emissions of transport activities expected to result from agglomeration and relocation of industrial premises. However, other environment-related issues that may result from such relocation decision can be equally important. For example, the contribution of heavy fleet and buses to dust, dirt, noise, vibration, traffic congestion, maneuvering difficulties, parking problems and potential accidents could be significant. These can occur while travelling to/from, as well as between the 4 company premises, that are currently located in highly congested and populated urban areas. Additionally, the current location of the company in an urbanised setting causes severance and visual intrusion. All these problems will be potentially relieved in case of company relocating to 6^{th} of October industrial area. Other factors which are not transport related include the industrial benefit of agglomeration of activities as well as the potential high price of released land currently occupied by the four premises.

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