carbon ▸ cost ▸ community ▸ climate

Life-Cycle Carbon Footprint Auditing for Proposed Township at Zendewadi

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Business-As-Usual Scenario:

Under Business-As-Usual Conditions, the anticipated Carbon Footprint over the Project Lifespan is expected to be 3.15 Million Tonnes of CO2e (over 50 years). This equates to an annual footprint of 63,030 Metric Tonnes CO2e/year.

The largest contributor to this footprint is Electricity Consumption during the use-phase of the township (from residential and commercial buildings) which represents approximately 52.6% of the footprint. This is followed by embodied carbon emissions from manufacturing of construction materials contributes 18.2 % emissions. Finally, emission from Grid-Related Transmission and Distribution Losses from the electricity consumed and fuel consumption during the construction phase, representing approximately 17.9 % of the footprint. Finally, emissions from waste management contributes 4.9%.

Loss of shrubland from Land-Use Change contributes approximately 27,118 Metric Tonnes of CO2e over 50 years stemming from reduced sequestration capacity.

Low Carbon Scenario:

The individual flats in all the apartments are proposed to be equipped with various features resulting in GHG emission mitigation over the years of operation of the township. The proposed 'Green Features' are:

- Reduced Window to Wall Ratio - enter WWR
- Natural Ventilation
- Ceiling Fans in all Habitable Rooms
- Energy-Saving Light Bulbs - Internal Spaces
- Energy-Saving Light Bulbs - Common Areas and External Spaces
- Lighting Controls for Common Areas and Outdoors
- Energy Efficient Refrigerators and Clothes Washing Machines
- Organic waste composting

Under the Low Carbon scenario the anticipated Carbon Footprint over the Project Lifespan is expected to be 2.25 Million Tonnes of CO2e (over 50 years). This equates to an annual footprint of 44,944 Metric Tonnes CO2e/year.

GHG Mitigation:

Energy conservation due to energy efficient building design and renewable energy use is expected to yield GHG savings of 0.60 Million Tonnes of CO2e (over 50 years). This equates to an annual footprint mitigation of 11,995 Metric Tonnes CO2e/year. This also reduces GHG emissions from Grid-Related Transmission and Distribution Losses by 0.20 millions Million Tonnes of CO2e (over 50 years) or an annual mitigation of 4,081 Metric Tonnes CO2e/year.

Reduced methane emissions due composting of solid waste generated during the use-phase is expected to yield GHG savings of 0.093 Million Tonnes of CO2e (over 50

years). This equates to an annual footprint mitigation of 1,865 Metric Tonnes CO_2e/year. Reduced transportation needs stemming from on-site composting and management of waste at sites located within a close proximity of the township will yield savings of approximately 21 Metric Tonnes CO_2e/year.

Plantation of trees on site post the construction phase will sequester approximately 6,558 Metric Tonnes CO_2e over 50 years. Nonetheless, this is still much lower than the sequestration capacity of the existing shrubland and leads to a net sequestration-capacity loss of 20,560 Metric Tonnes CO_2e over 50 years.

1. Introduction

This project report has been prepared by cBalance Solutions Private Limited, Pune India.

This report seeks to quantify and provide a comprehensive overview of the carbon footprint of townships during their life phases (cradle to gate). This will facilitate the understanding of environmental impacts of a township at every stage of its life. This study will also help establishing the environmental benchmarks for the real estate/ city specific studies in future.

2. Project Objective

To conduct Life-Cycle Carbon Footprint Auditing for a proposed township in Zendewadi, Pune and provide general recommendations on how to reduce the carbon footprint.

Project activities included the following:

- **Operational Process Mapping:** Mapping of activities and processes across relevant departments (construction and operations) that influence building carbon footprint was done.

- **Data Collection & Verification:** Data for deforestation, Energy (Fossil Fuels, Biomass Fuels, Captive Power Generation), Purchased Electricity, Water, Waste & Wastewater, Purchased Goods Construction & Building Materials, Purchased services - outsourced contracted services during *Construction* and *Operation* phases was collected and verified.

- **Carbon Footprint Auditing - Using India-specific Emission Factors Database:** Secondary research and Scope 1, Scope 2, Scope 3 GHG Emissions calculations and analysis for the construction and operation phase for the proposed township was done.

- **Scenario Modelling:** Comparison of scenarios where conventional construction & building materials are used vs. low-carbon embodied construction & building materials are used was carried out.

- **Recommendations & Reporting:** GHG Inventory of the construction Project, best-practices and recommendations to minimize the carbon footprint of the construction project were reported.

3. Project Scope

The geographical scope of this project was the area of a proposed residential project by Destination Reality Developers in Zendewadi village, of Pune district. Total construction area of the project is 2,65,854.01 sqm, depicted in Figure 1: Sector – wise map of proposed Zendewadi township.

Figure 1: Sector – wise map of proposed Zendewadi township

Inventorying and subsequent analysis of GHG emissions associated with the proposed township was performed using four standards simultaneously; each of them addressing all key sources of emissions across the project life-cycle but enabling a distinctive set of assessment of emissions that were direct outcomes of the protocol's architecture and approach to structuring of information. The following four standards were used in succession and all except the Community-Scale Standard (Nos. 4), yield a comprehensive footprint assessment of the entire project life-cycle. The Community-Scale Protocol is related, by design, specifically to the use-phase of built habitats

1. Corporate GHG Inventory
2. Corporate Value Chain (Scope 3) accounting and reporting standard
3. Product Life Cycle Accounting and Reporting Standard
4. Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

3.1 *Scope Definition*

3.1.1 Corporate GHG Inventory

This GHG Protocol's Corporate Standard provides standards and guidance for companies and other types of organizations preparing a GHG emissions inventory. It

covers the accounting and reporting of the six greenhouse gases covered by the Kyoto Protocol—Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur Hexafluoride (SF_6). While this standard has been followed almost entirely for this project, the aspect of 'materiality threshold' as defined by the concept of 'key categories' has been incorporated from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. This is discussed as part of the 'Completeness' attributes of the GHG Inventory and described later in the report.
The standard requires adherence to the key principles of Relevance, Completeness, Consistency, Transparency, and Accuracy. These principles and measures taken to adhere to them in the execution of this project are discussed below.

RELEVANCE: It must be ensured that the GHG inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users – both internal and external to the company. Relevance can be ensured by appropriate and thoughtful selection of Operational and Organizational Boundary (described later). The selection of an appropriate inventory boundary that reflects the substance and economic reality of the company's business activities, processes and relationships, not merely its legal form, is pivotal to this process and has been addressed in compiling the GHG inventory for the proposed Zendewadi project.

COMPLETENESS: The GHG inventory must account for and report on all GHG emission sources (i.e. Scopes) and activities (i.e. within each Scope) within the chosen inventory boundary and any specific exclusions must by disclosed and justified. Exclusions of activities from the Inventorying process may be the outcome of limiting constraints such as a lack of primary data, high uncertainty level of available secondary data, or the cost of gathering data. Theoretically a materiality threshold (a minimum emissions accounting threshold), stating that a source not exceeding a certain size can be omitted from the inventory, can be implemented to address unquantifiable emission sources. However, the practical implementation of such a threshold is not compatible with the completeness principle of the GHG Protocol Corporate Standard. Instead, companies must transparently document and justify cases where emissions have not been estimated, or estimated at an insufficient level of quality.

CONSISTENCY: The process of inventorying must use consistent methodologies across time boundaries to allow for meaningful comparisons of emissions over time. To enable this, a GHG inventory report must transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.

TRANSPARENCY: All relevant issues must be addressed by the Inventory process in a factual and coherent manner, based on a clear audit trail. The reported activity must disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used. The standard requires information to be recorded, compiled, and analyzed in a way that enables internal reviewers and external verifiers to attest to its credibility and enable a third party to derive the same results if provided with the same source data. The project report addresses transparency related requirements by providing a comprehensive

listing of all assumptions, simplifications, emission factor sources, and technical references in Appendix along with relevant equations and mathematical and scientific relationships used data processing and analysis required for calculating GHG emissions.

ACCURACY: The Corporate Standard requires that the quantification of GHG emissions is systematically neither over nor under actual emissions, and that uncertainties are reduced as far as possible. The process must be designed to achieve sufficient accuracy to ensure integrity of the reported information and enable users to determine its reliability with reasonable assurance. This project effort incorporated extensive efforts to ensure accuracy of the activity data obtained, collated and transmitted by the reporting entity through:
a) Administering rigorously designed data collection questionnaires,
b) Providing guidance to the entity with respect to best-practices to be followed for ensuring high data quality
c) Establishing the preferred units for data collection and suggesting acceptable surrogate units for activity data collection if data was not available in the ideally preferred form
d) Establishing a priority list of emission source activities for which primary data was imperative and activities for which secondary data would be acceptable

The GHG Inventory process's accuracy is also augmented by use of well documented Tier 2 and Tier 3 GHG Emission Factors wherever possible and use of Tier 1 default emissions factors as the least preferred option. The emission factors used and their sources are presented in Appendix.

The Corporate GHG Inventory accounts for three major Greenhouse Gases: Carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O). Emissions of these gases have been accounted for activities classified as part of Scope 1, Scope 2, and relevant significant Scope 3 emission sources. Emission sources leading to generation of the other 3 Kyoto Protocol Gasses, namely HFCs, PFCs, and SF6, were not considered as '*key categories*' (or below the materiality threshold as defined earlier as part of the 'Completeness' attributes of the project) by project's technical advisory team.

Implementation of the Corporate Standard for GHG Inventorying requires definition of an Organizational and Operational Boundary.

3.2 *Organizational Boundary Definition*

For corporate reporting, two distinct approaches can be used to consolidate GHG emissions: the equity share and the control approach.

Equity share approach: Under the equity share approach, a company accounts for GHG emissions from operations according to its share of equity in the operation. The equity share reflects economic interest, which is the extent of rights a company has to the risks and rewards flowing from an operation.

Control approach: Under the control approach, a company accounts for 100 percent of the GHG emissions from operations over which it has control. It does not account for GHG emissions from operations in which it owns an interest but has no control. Control can be defined in either financial or operational terms. When using the control approach to consolidate GHG emissions, companies shall choose between either the operational control or financial control criteria.

Source: The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard

The criterion for setting the Organizational Boundary for this Inventory is the Operational Control approach. The Standard stipulates that a company has operational control over an operation if the company or one of its subsidiaries has the full authority to introduce and implement its operating policies in the operations. According to this interpretation of operational control and based on discussions with the Reporting Entity's Management personnel, contractual activities at the production facility are entirely within the operational control of the Reporting Entity and hence 100% of the emissions from the activities are reported in this Inventory and are considered as emissions over which the Reporting Entity has 100% control.

3.3 *Operational Boundary Definition*

Subsequent to organizational boundaries definition in terms of the operations that it owns or controls, The Corporate Value Chain Standard requires specifying of operational boundaries which entails identifying emissions associated with its operations, categorizing them as direct and indirect emissions, and choosing the scope of accounting and reporting for indirect emissions.

Direct GHG emissions are emissions from sources that are owned or controlled by the company.
Indirect GHG emissions are emissions that are a consequence of the activities of the company but occur at sources owned or controlled by another company.

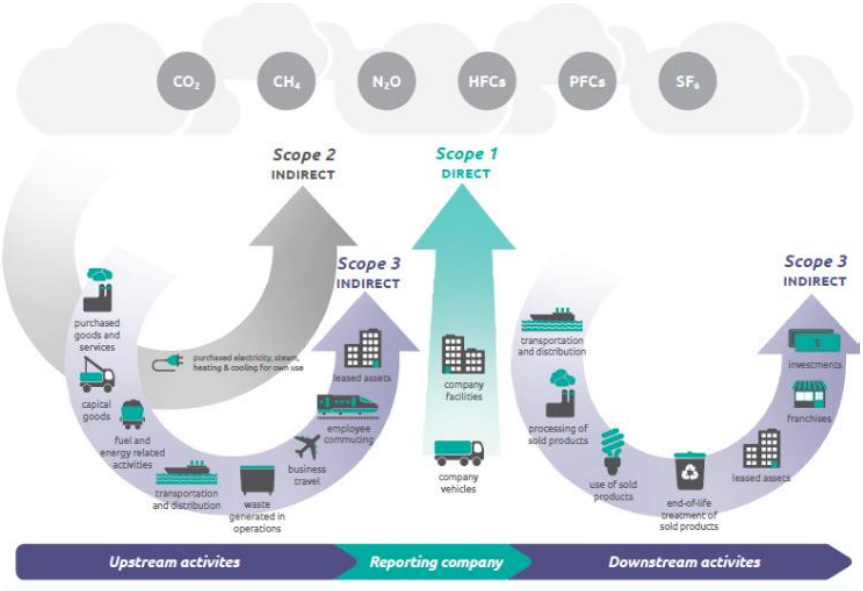
Furthermore, to improve transparency, and provide utility for different types of organizations three "scopes" (scope 1, scope 2, & scope 3) are defined for GHG accounting & reporting

Scope 1: These are direct GHG emissions from sources that are owned or controlled by the company. For example, emissions from combustion in owned or controlled facilities and vehicles.
Scope 2: These are indirect GHG emissions occurring as a consequence of GHG emissions from the generation of purchased electricity by the company.
Scope 3: These comprise other indirect emissions except those accounted for as Scope 2 emissions. They are a consequence of the activities of the company, but occur from sources not owned or controlled by the company and are an optional reporting category. Examples include embodied carbon emissions from manufacturing of materials used by a company, third party deliveries, business travel activities and use of sold products and services.

Source: The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard

The general framework for Operational Boundary setting is depicted in Figure 2: Activity Differentiation according to Scope 1, Scope 2 & Scope 3 GHG Emissions

Figure 2: Activity Differentiation according to Scope 1, Scope 2 & Scope 3 GHG Emissions



Source: "Greenhouse Gas Protocol – Product Life Cycle Accounting and Reporting Standard" – World Resource Institute

The Operational Boundary for the Corporate GHG Inventory compiled as part of this Project is defined as per:

1. Greenhouse Gas Protocol Corporate Standard
2. Corporate Value Chain (Scope 3) Accounting and Reporting Standard
3. Product Life Cycle Accounting and Reporting Standard
4. GHG Protocol for Cities

The relationship between the four GHG accounting standards mentioned above is explained in Figure 3:

Figure 3: Relationship diagram of a) Greenhouse Gas Protocol Corporate Standard, b) Corporate Value Chain (Scope 3) Accounting and Reporting Standard, c) Product Life Cycle Accounting and Reporting Standard and d) GHG Protocol for Cities for GHG inventory report

3.3.1 Total GHG emissions (scope 1, scope 2 and scope 3)

The three "scopes" (scope 1, scope 2 and scope 3) are defined for GHG accounting & reporting as:

Scope 1: These are direct GHG emissions from sources that are owned or controlled by the company. For example, emissions from combustion in owned or controlled facilities and vehicles.

Scope 2: These are indirect GHG emissions occurring as a consequence of GHG emissions from the generation of purchased electricity by the company.

Scope 3: These comprise other indirect emissions except those accounted for as Scope 2 emissions. They are a consequence of the activities of the company, but occur from sources not owned or controlled by the company and are an optional reporting category. Examples include embodied carbon emissions from manufacturing of materials used by a company, third party deliveries, business travel activities and use of sold products and services.

3.3.2 Scope 3 Emissions

Categories of Scope 3 emissions are listed in

Table 1: GHG Inventory Operational Boundary Definition according to Scope 3 GHG Protocol

	Emissions Category	Emissions Sub-category	Within Operational Boundary?	Scope
Scope 1	**Direct** Energy Consumption	Fuel Combustion & Refrigerants	Yes	1
		Captive Power Generation	NA	
Scope 2	**Indirect** Emissions	Purchased Electricity	Yes	2
		Purchased Water	Yes	
1	Purchased goods and services	Production related Procurement	Yes	3
		Non Production related Procurement	No	
2	Capital Goods	Capital goods (Complete LCA)	No	
3	Fuel- and energy-related activities	Upstream Emissions of Purchased Fuels, Electricity and T & D Losses	Yes	
4	Upstream transportation and distribution	Procurement of raw materials	Yes	
5	Waste generated in operations	Solid Waste	Yes	
		Wastewater & Waste Transportation	Yes	
6	Business Travel	Business Travel & Accommodation	No	
7	Employee Commuting	Employee Commuting	No	
8	Upstream leased assets	Upstream leased assets	No	
9	Downstream transportation and distribution	Transportation, Storage in Warehouses & Retail Stores	No	
10	Processing of Sold Products	Processing of Sold Products	No	
11	Use of sold products	Fuel Consumption	Yes	
12	End-of-life treatment of sold products	Waste generation	No	
13	Downstream leased assets	Downstream leased assets	NA	
14	Franchises	Franchises	NA	
15	Investments	Investments	NA	

Explanation of categories under the Scope 3 Emissions according to GHG protocol is given below:

1. **Purchased Products & Services:**

   This category includes all upstream (i.e., cradle-to-gate) emissions from the production of products purchased or acquired by the reporting company in the reporting year. Products include both goods (tangible products) and services (intangible products).

   Cradle-to-gate emissions include all emissions that occur in the life cycle of purchased products, up to the point of receipt by the reporting company (excluding emissions from sources that are owned or controlled by the reporting company)

2. **Purchased Capital Goods**

   This category includes all upstream (i.e. cradle-to-gate) emissions from the production of capital goods purchased or acquired by the reporting company in the reporting year.

   Capital goods are final products that have an extended life and are used by the company to manufacture a product, provide a service, or sell, store, and deliver merchandise. In financial accounting, capital goods are treated as fixed assets or as plant, property, and equipment (PP&E).

3. **Upstream Energy (Fuel & Electricity) Emissions**

   This category includes emissions related to the production of fuels and energy purchased and consumed by the reporting company in the reporting year that are not included in scope 1 or scope 2.

4. **Upstream Transportation & Distribution**
   This category includes emissions from the transportation and distribution of products (excluding fuel and energy products) purchased or acquired by the reporting company in the reporting year in vehicles and facilities not owned or operated by the reporting company, as well as other transportation and distribution services purchased by the reporting company in the reporting year (including both inbound and outbound logistics).

5. **Waste generated in operations**

   This category includes emissions from third-party disposal and treatment of waste that is generated in the reporting company's owned or controlled operations in the reporting year. This category includes emissions from disposal of both solid waste and wastewater. Only waste treatment in facilities owned or operated by third parties is included in scope 3.

6. **Business Travel**

This category includes emissions from the transportation of employees for business-related activities in vehicles owned or operated by third parties, such as aircraft, trains, buses, and passenger cars. Companies may optionally include emissions from business travelers staying in hotels.

7. **Employee Commuting**

This category includes emissions from the transportation of employees & between their homes and their worksites. Companies may include emissions from teleworking (i.e., employees working remotely) in this category.

8. **Upstream Leased Assets**

This category includes emissions from operation of assets leased by the reporting company (lessee) in the reporting year and not included in scope 1 and scope 2 – reported by lessee.

9. **Downstream Transportation & Distribution**

This category includes emissions from transportation and distribution of products sold by the reporting company in the reporting year between the reporting company's operations and the end consumer (if not paid for by the reporting company), in vehicles and facilities not owned or controlled by the reporting company. This category includes emissions from retail and storage.

10. **Processing of Sold Products**

This category includes the emissions from processing of intermediate products sold in the reporting year by downstream companies (e.g., manufacturers)

11. **Use of sold products**

This category includes emissions from the use of goods and services sold by the reporting company in the reporting year. A reporting company's scope 3 emissions from use of sold products include the scope 1 and scope 2 emissions of end users. End users include both consumers and business customers that use final products.

12. **End-of-life treatment of sold products**

This category includes emissions from the waste disposal and treatment of products sold by the reporting company (in the reporting year) at the end of their life. This category includes the total expected end-of-life emissions from all products sold in the reporting year.

13. **Downstream Leased Assets**

This category includes emissions from operation of assets owned by the reporting company (lessor) and leased to other entities in the reporting year, not included in scope 1 and scope 2 – reported by lessor.

14. Franchises

This category includes emissions from operation of franchises in the reporting year, not included in scope 1 and scope 2 reported by franchisor.

15. Investments

This category includes emissions from operation of investments (including equity and debt investments and project finance) in the reporting year, not included in scope 1 or scope 2.

Source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard

3.3.3 Life-Cycle Stages Emissions

In order to calculate the carbon footprint of the proposed townships, the operations were divided into five different life-cycle stages. A life-cycle stage looks at the carbon emissions over the life-span of any activity, following the cradle to grave approach. The following is a list of the different stages that were identified, based on the different types of activities conducted in each stage:

1. Pre-Construction Operations:

This stage primarily focuses on the emissions from the activities related to Material Acquisition and Pre-Processing, that take place before the construction begins. It includes purchasing and transportation of raw materials and construction equipment, along with accounting for the activities related to labour commuting and waste management.

2. During Construction Operations:

This stage looks into the emissions from all activities that take place during the construction of the proposed township. It includes excavation, waste removal and recycling, construction equipment and vehicular operations, amount of water and electricity purchased, afforestation and labour commuting.

3. Post-Construction Operations:

This stage focuses on emissions from distribution and storage, dealing with waste management, transportation of construction equipment and labour commuting.

4. Building-Use Phase:

This stage deals with all activities that take place once the construction is over, and the buildings are ready for use. This section includes the emissions from the amount

of purchased electricity, water and fuel use based on the type of occupancy of each building, the fugitive emissions from mining, processing, storage and transportation of coal, oil and natural gas systems, transportation within the township, waste disposal and treatment and emissions from any industrial or agricultural activities.

5. Abandonment:

This stage is the end of life of the township, dealing with the emissions from demolishing, waste removal and waste recycled.

Figure 4 - LCA Diagram for Building Life Cycle Stages

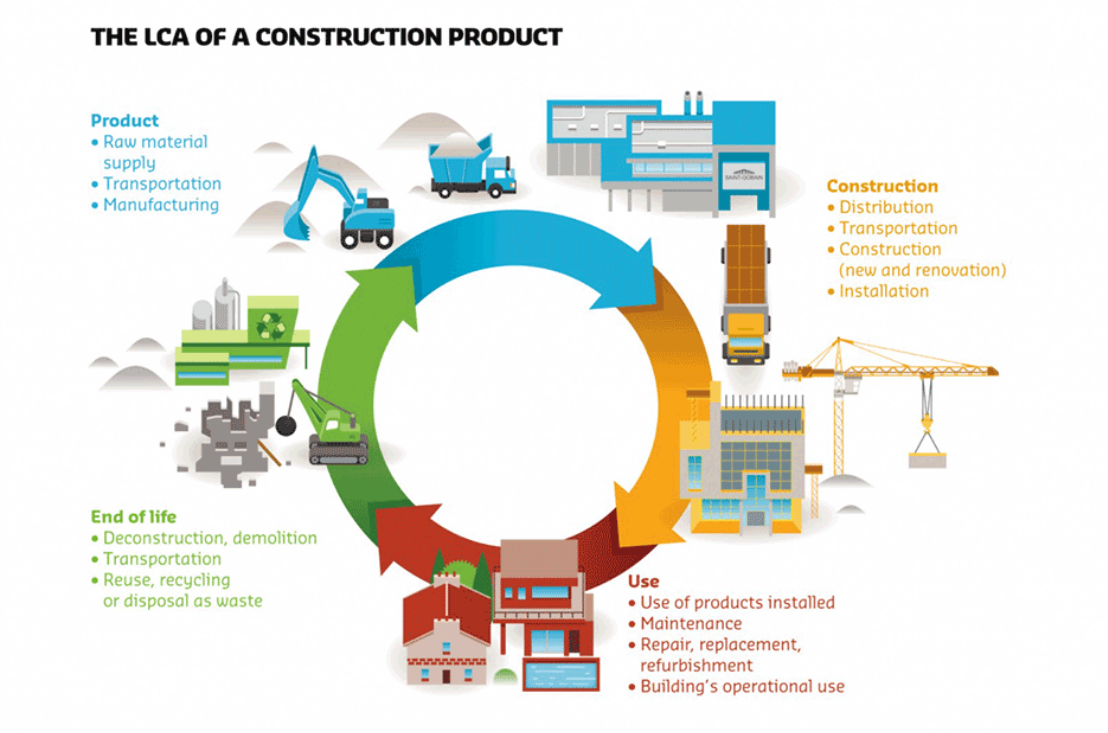
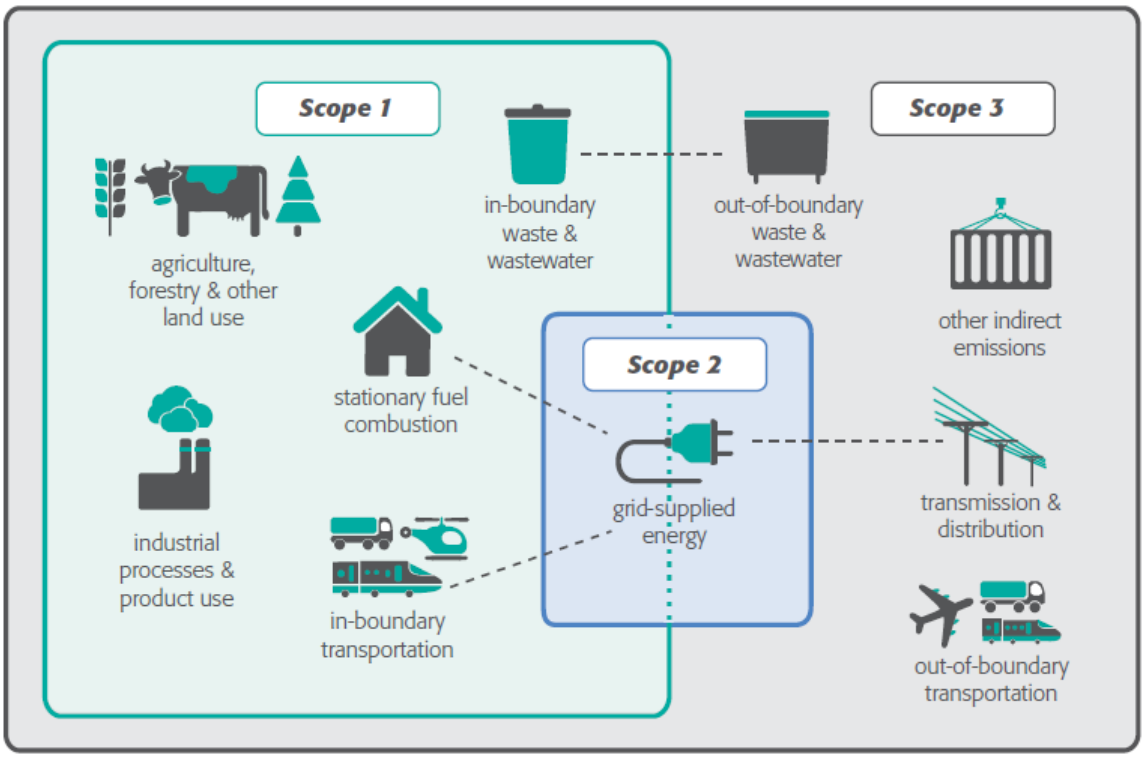


Image Source: https://www.saint-gobain.com/en/group/strategy

3.3.4 GHG Protocol for Cities (GPC)

The GHG Protocol for cities states that it can be used for assessing the GHG emissions of a geographically defined, subnational area. Although the GPC is primarily designed for cities, the accounting framework can also be used for boroughs or wards within a city, towns, districts, counties, prefectures, provinces, and states. Hence the GHG emissions for the proposed township are analyzed by considering the geographical area as the organizational boundary. The GHG emissions are accounted as per the emission sources and they further categorized into Scope1, Scope2 and Scope3. The categorization of the sources are illustrated in Figure 5: Sources and boundaries of city GHG emissions.

Figure 5: Sources and boundaries of city GHG emissions



The emission sources against which GHG accounting and reporting is done under GPC are listed in Table 2: GHG Inventory Operational Boundary Definition according to City GHG Protocol. The Scope 1, Scope 2 and Scope 3 emissions from each listed source are colour coded as per the reporting requirements. In our analysis however, we have considered the emission sources and category marked as "Yes" as they were the most relevant for the case of township.

Table 2: GHG Inventory Operational Boundary Definition according to City GHG Protocol

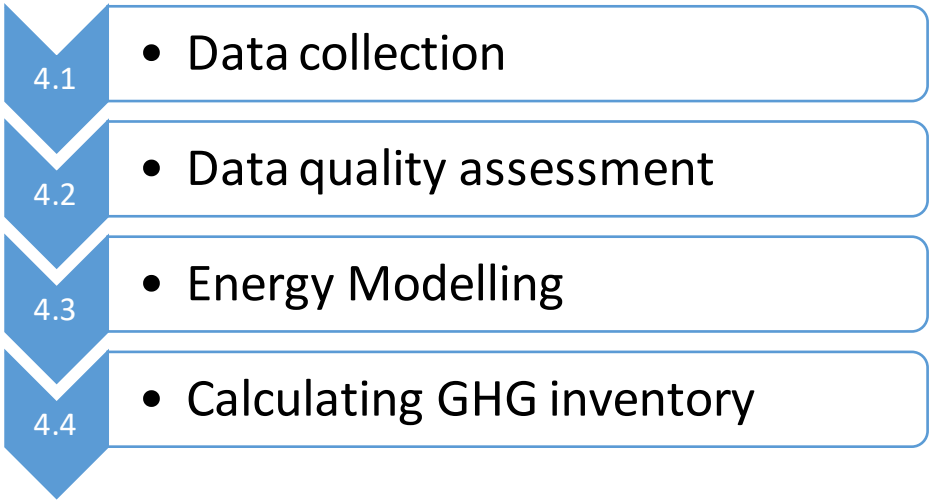
Sectors and Sub – sectors	Scope 1	Scope 2	Scope 3
Stationary Energy			
Residential buildings		Yes	Yes
Commercial and institutional buildings and facilities		Yes	Yes
Manufacturing industries and construction			
Energy industries			
Energy generation supplied to the grid			
Agriculture, forestry, and fishing activities			
Non-specified sources			
Fugitive emissions from operations of coal			
Fugitive emissions from oil and natural gas systems			
Transportation			
On-road			
Railways			
Waterborne Navigation			
Aviation			
Off-Road			
Waste			

Disposal of solid waste generated in the city			Yes
Disposal of solid waste generated outside the city	Yes		
Biological treatment of waste generated in the city			Yes
Biological treatment of waste generated outside the city			
Incineration and open burning of waste generated in the city			
Incineration and open burning of waste generated outside the city			
Wastewater generated in the city			Yes
Wastewater generated outside the city			
Industrial Processes and Product Use			
Industrial processes			
Product use			
Agriculture , Forestry and Other Land Use			
Livestock			
Land			
Aggregate sources and non-CO2 emission sources on land			
Other Scope 3			
Other Scope 3			

Reference:		
All The colored cell depict sources covered by the GPC		
Sources required for BASIC+ reporting		
Sources required for BASIC reporting		
Sources required for territorial total but not for BASIC reporting		
Sources included in Other Scope 3		

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

4. Research and Analysis



4.1 *Data Collection*

The data collection process commenced with devising and administering a questionnaire in alignment with data needs identified by the GHG Corporate Inventory, Product Life Cycle GHG Emission Accounting and Reporting Standard, Corporate Value Chain (Scope 3) Accounting and Reporting Standard and GHG

Protocol for Cities Reporting Standard. The questionnaire (presented in Appendix A) encompassed all the previously mentioned organizational boundary stakeholders, related to all operational boundary activities, and comprised all product life cycle stage considered within the project boundary.

4.2 *Data quality Assessment*

Primary activity data related to emission sources was available to cBalance through electronic records provided by the client. The following exercises were carried out to ensure accuracy, completeness and reliability of data: cross-referencing of data from multiple documents and other QA-QC processes.

4.3 *Energy modelling*

According to the data provided for the number and type of apartments in the township, energy modelling was done using the carpet area data for each type of unit. This provided us with a realistic approximation of the energy required for the operation for each unit type and further used for inventorying the Scope 2 GHG emissions caused by the residential and commercial buildings. The following seven (7) energy conservation features were modelled:

1. Reduced Window to Wall Ratio - enter WWR
2. Natural Ventilation
3. Ceiling Fans in all Habitable Rooms
4. Energy-Saving Light Bulbs - Internal Spaces
5. Energy-Saving Light Bulbs - Common Areas and External Spaces
6. Lighting Controls for Common Areas and Outdoors
7. Energy Efficient Refrigerators and Clothes Washing Machines

4.4 *Calculation of GHG Inventory*

4.4.1 Scope 1 Emissions

As per the Life Cycle Carbon Footprint Operational Boundary (refer to Table 2) Scope 1 emissions include direct energy consumption activities, such as fuel combustion& energy and captive power generation. More specifically, the above activities focus on the three categories of fossil fuels, refrigerants and captive power generation. For the Zendewadi township, the major Scope 1 categories therefore include biomass gain / loss due to the proposed construction activities to be carried out and purchased fuel (mainly diesel) used for powering construction equipment during the construction phase.

4.4.1.1 Direct emissions from fuel combustion

At for the construction and operation of the proposed township at Zendewadi, direct emissions comprise diesel powered construction equipment used during the estimated 6 years of construction phase (Trailors, transit mixers, pickup tempo, Hydra, JCB, Loader and mobile crane).

The methodology for estimating direct emissions from fuel combustion was the following:

Total emissions from fuel use

Emissions GHG, $_{fuel}$ = Fuel Consumption × Emission Factor
Where,
Emissions GHG, $_{fuel}$ = Emission of a given GHG by type of fuel (kg GHG)
Fuel Consumption = Amount of fuel combusted (Litre)
Emission factor = Default emission factor of a given GHG by type of fuel (kg gas/litre)

4.4.1.2 AFLOU Emissions

Forest Carbon Stock Change

Land-use change impact of the activity results in lost carbon sequestration capacity of the forest area. This is estimated through the method below:

Total emissions from forest carbon stock change[1]:

Emissions $_{GHG,\ forest\ Carbon\ stock\ change}$ =

$$Carbon\ stock\ per\ hectare\ of\ \ forest\ area \times Deforestation\ Area\ (ha) \times {}^{44}/_{12}$$

Where,

Emissions $_{GHG,\ forest\ carbon\ stock\ change}$ = emission of a given GHG from forest carbon stock change (kg GHG)

Carbon Stock of forest = carbon sequestrated of a given area of forest land (C/hectare of forest land)

Deforestation Area = Area of deforestation of forest land (hectare)
Conversion C to CO_2 = 44/12 (Molecular weight)

4.4.2 Scope 2 Emissions

4.4.2.1 Indirect emissions from purchased electricity and water

Emissions from the generation of purchased or acquired electricity, steam, heating, or cooling consumed by the reporting company fall under the Scope 2, Indirect Emissions (upstream activities).

The method of calculating the total emissions from electricity use is the following:

Emissions GHG, $_{Purchased\ Electricity}$= Electricity Consumption (kWh) × Emission Factor
Purchased electricity

Where,

[1] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 4: Forest Land

Emission Factor GHG, $_{Purchased\ Electricity}$= Grid GHG Emission Factor for the Region (Maharashtra)

The above calculation also applies to emissions from purchased water (replaced by the national emission factor for municipal water supply, multiplied by the number of litres consumed).

4.4.3 Scope 3 emissions

4.4.3.1 Purchased Products and Services

> This category includes all upstream (i.e., cradle-to-gate) emissions from the production of products purchased or acquired by the reporting company in the reporting year. Products include both goods (tangible products) and services (intangible products).
>
> Cradle-to-gate emissions include all emissions that occur in the life cycle of purchased products, up to the point of receipt by the reporting company (excluding emissions from sources that are owned or controlled by the reporting company)
>
> *Source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard*

Purchased Products & Services category comprised primarily the purchase of Raw Materials, required for the production of the final four products- production-related purchases.

The categories of purchased intermediate goods comprised:

- Raw materials for construction
- Aluminum - semi-finished & finished products
- Cement
- Ceramic tiles
- Glass - Float Glass/Toughened Glass
- Steel Bar/Rod & Other finished steel products

The quantities of the purchased raw materials were provided.

The method of calculating the total emissions from purchased raw materials is the following:

Emissions GHG, $_{Raw\ Materials}$= ***Raw materials procured (kg) × Emission Factor*** $_{Raw\ materials}$

Where,
Emission Factor GHG, $_{Raw\ Material}$= Relevant emission factor for a specific material category (e.g. cement or ceramic tiles)

4.4.3.2 Purchased capital goods

This category includes all upstream (i.e. cradle-to-gate) emissions from the production of capital goods purchased or acquired by the reporting company in the reporting year

Capital goods are final products that have an extended life and are used by the company to manufacture a product, provide a service, or sell, store, and deliver merchandise. In financial accounting, capital goods are treated as fixed assets or as plant, property, and equipment (PP&E).

Source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard

The GHG protocol stipulates that companies are not required to include non-attributable processes, but can if they wish.

In case of the proposed township, the process is not assessed for GHG emissions, as the emissions are deemed to be immaterial in relation to, for example, purchased Raw Materials.

4.4.3.3 Upstream Energy (Fuel and Electricity) Emissions

This category includes emissions related to the production of fuels and energy purchased and consumed by the reporting company in the reporting year that are not included in scope 1 or scope 2.

Source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard

This category considers fugitive emissions which are calculated taking into account the Scope 1 and Scope 2 activity data (in this case, consumption of electricity) thereby encompassing purchased fuels, electricity, and electricity T&D losses.

Emissions GHG, $_{Fuel\ Supply\ Chain}$ **= *Fuel Consumption (litres, kg or kwh) × Emission Factor,*** $_{Fuel\ Supply\ Chain}$

Where,
Emission Factor GHG, $_{Fuel\ Supply\ Chain}$ = Relevant emission factor for a type of fuel and its corresponding fugitive emission rate (e.g. emissions from Exploration, Production, Transmission, Upgrading, Refining, and Distribution of liquid fossil fuels used)

Total emissions from Electrical AT&C Losses

TOTAL EMISSIONS $_{GHG,\ electricity\ AT\&C\ losses}$ **= *Emission Factor*** $_{GHG,\ electricity}$ **x Electricity Consumption (kWh) / (T&D Losses Correction Factor)**

Where,

T&D Loss Correction Factor (including impact of Aux. Power Consumption) =

$$\frac{Gross\ Energy\ Generated + Energy\ Purchased\ from\ Non-utilities + Energy\ Imported\ from\ Other\ Countries}{[Energy\ sold\ In\ India + Exported]}$$

4.4.3.4 Upstream Transportation and Distribution Emissions

This category includes emissions from the transportation and distribution of products (excluding fuel and energy products) purchased or acquired by the reporting company in the reporting year in vehicles and facilities not owned or operated by the reporting company, as well as other transportation and distribution services purchased by the reporting company in the reporting year (including both inbound and outbound logistics).

Source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard

Assessment of Upstream Transportation & Distribution has included tier 1 suppliers transportation and distribution (of raw materials and the waste generated). Majority of the upstream transportation activities were carried out through road transportation.

The method of calculating the total emissions from upstream logistics and distribution is the following:

Emissions GHG, $_{Road\ transportation}$ ***= Distance travelled (kg-km) × Emission Factor,*** $_{Road\ transport}$

Where,
Emission Factor GHG, Road transportation= Relevant emission factor for a road truck

4.4.3.5 Waste generated in operations

This category includes emissions from third-party disposal and treatment of waste that is generated in the reporting company's owned or controlled operations in the reporting year. This category includes emissions from disposal of both solid waste and wastewater. Only waste treatment in facilities owned or operated by third parties is included in scope 3.

Source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard

The following comprised this category which was accounted for in the emissions:

- Biodegradable waste generated during construction phase
- Inorganic waste generated during construction phase
- Wastewater generated during operation phase
- Inorganic waste generated during operation phase

The waste GHG emissions contribution was calculation as follows:

Emissions GHG, $_{Waste}$ ***= Waste produced (kg or litres) × Emission Factor*** $_{Waste}$
Where,
Emission Factor GHG, $_{Waste}$ = Relevant emission factor for a type of waste not recycled

For instance, CH4 Emission Factor for unsegregated landfill waste calculated as below:

$CH_4EF_{unseg\text{-}landfilled}$

$$= (MSW_F \cdot MCF \cdot DOC_F \cdot DOC_{MW} \cdot F \cdot [16 / 12] - R) \cdot (1 - O_X)$$

MSW_F = fraction of MSW disposed to solid waste disposal sites[2]

MCF =Methane Correction Factor for Unmanaged - deep (>5m waste) Landfills[3]

DOC_F =fraction DOC dissimilated[4]
F =fraction of CH4 in landfill gas[5]
R =Methane Recovery factor[6]
O_X =Oxidation Factor[7]

5. Results and Analysis

The GHG emissions are calculated for the Business-as-usual scenario and Low carbon scenario for the lifecycle of the proposed township. In the Low carbon scenario the energy modelling for each type of apartment building was done by taking into account the proposed green measures which resulted in possible mitigation of GHG emissions.

5.1 *Business-as-Usual Scenario*

5.1.1 Activity Data

The GHG inventory was calculated according to various activities which are categorized under Scope 1, Scope 2 or Scope 3. Summary of the calculations for GHG Emissions of each activity under Business – as – Usual scenario is shown in Table 3: Activity Data for BAU.

[2] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 5. Chapter 2: Waste Generation, Composition and Management Data TABLE 2.A1 TABLE 2A.1 MSW GENERATION AND MANAGEMENT DATA - BY COUNTRY AND REGIONAL AVERAGES
[3] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 5. Chapter 3: Solid Waste Disposal TABLE 3.1 SWDS CLASSIFICATION AND METHANE CORRECTION FACTORS (MCF)
[4] Source: Bhattacharyya - Estimation of Methane Emission from Landfill sites at National Level, sheet 7; UBA (2006), S. 5 (laut Rettenberger/Stegmann 1997); IPCC (2006), p. 3.13
[5] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 5. Chapter 3: Solid Waste Disposal, 3.2.3 Choice of emission factors and parameters, FRACTION OF CH4 IN GENERATED LANDFILL GAS (F)
[6] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 5. Chapter 3: Solid Waste Disposal,TABLE 3.2 OXIDATION FACTOR (OX) FOR SWDS
[7] Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 5. Chapter 3: Solid Waste Disposal, 3.2.3 Choice of emission factors and parameters, METHANE RECOVERY (R)

Table 3: Activity Data for BAU

Activity Type	Activity Data	Units	GHG Emission (tonne CO2e)	% of total Carbon footprint
Scope 1				
Biomass Loss	22,480,021	m2-year	27,118	0.86%
Fuel Use- Site Construction	1,303	kiloliters (Fuel)	3,468	0.11%
Subtotal			***30,586***	***0.97%***
Scope 2				
Electricity	1.86 billion	kwh	1,658,714	52.6%
Water	70.7 million	kiloliters	141,755	4.50%
Subtotal			***1,800,469***	***57.1%***
Scope 3				
Construction Materials	456,359	tons	572,916	18.2%
Logistics	9,271	kiloliters (fuel)	24,676	0.78%
Logistics	15,992,037	ton-km (transported material)	1,050	0.03%
Waste	236,984	tons	157,776	5.01%
Electricity T&D losses	0.56 billion	kwh	564,465	17.9%
Subtotal			***1,320,883***	***41.9%***
Total GHG Emissions			***3,151,939***	

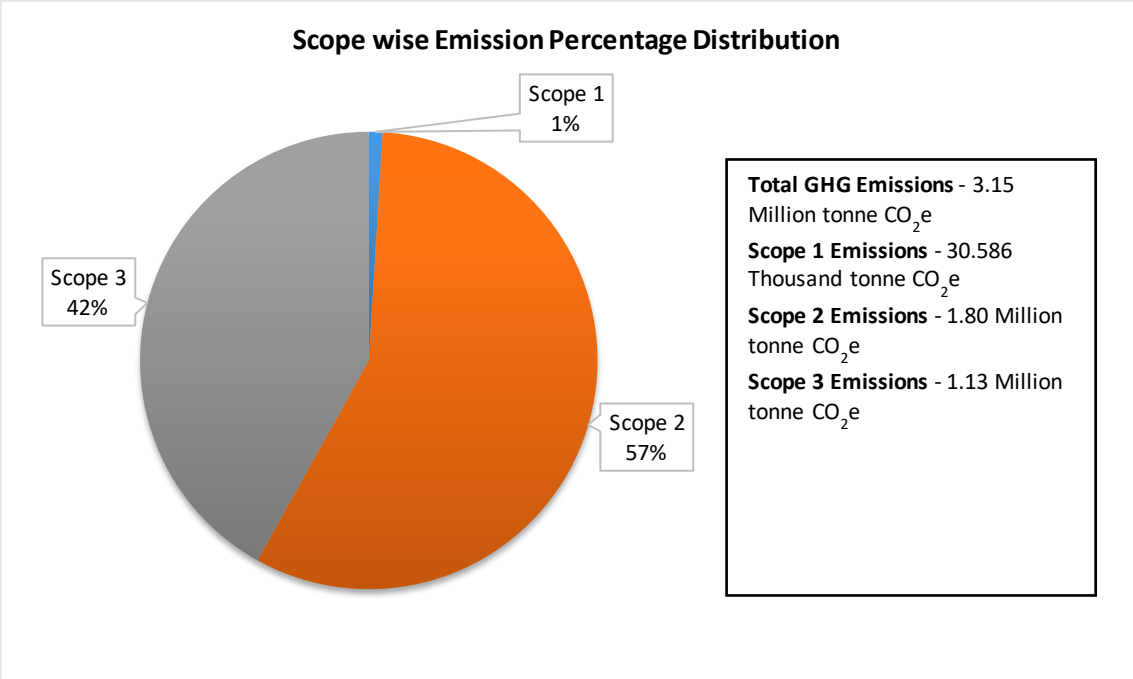
5.1.2 Scope wise Emissions

Scope wise emissions during the BAU scenario of the construction and operation of the proposed township are:

Table 4: Scope-wise emissions (BAU scenario)

Scopes	Footprint	Percentage Emissions
	MtCO2e	%
Scope 1	30,586	0.97%
Scope 2	1,800,469	57.1%
Scope 3	1,320,883	41.9%
Total	3,151,939	

Figure 6: Scope-wise emissions (BAU scenario)



5.1.3 Scope 3 Protocol Category – wise Emissions

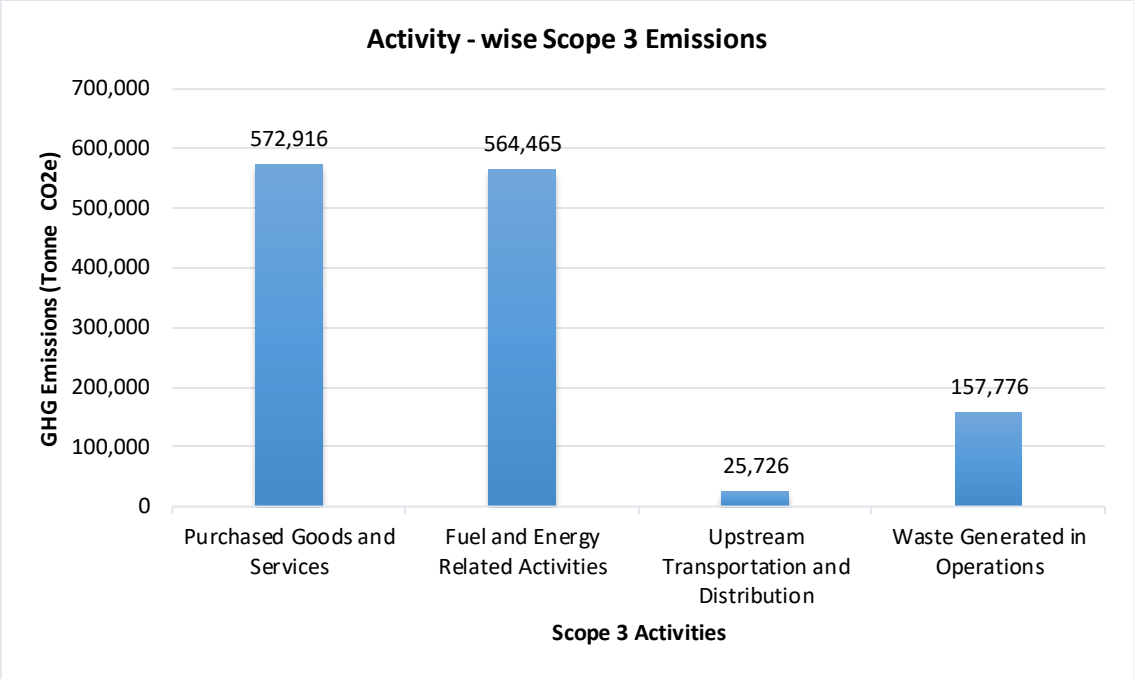
The GHG emissions for each significant category of the scope 3 GHG protocol are as follows:

Table 5: Scope 3 Protocol Activities Emissions (BAU scenario)

Scopes	Scope 3 Protocol Categories	Footprint	Percentage Emissions
		MT CO2e	%
Scope 1	Biomass Gain/Loss (AFOLU)	27,118	0.86%
Scope 1	Purchased Fuel	3,468	0.11%
Scope 1		30,586	0.97%
Scope 2	Purchased Electricity	1,658,714	52.6%
Scope 2	Purchased Water	141,755	4.50%
Scope 2	Purchased Heat	0	0.00%
Scope 2		1,800,469	57.1%
Scope 3	Purchased Goods and Services	572,916	18.2%
Scope 3	Capital Goods	0	0.00%
Scope 3	Fuel and Energy	564,465	17.9%

	Related Activities		
Scope 3	Upstream Transportation and Distribution	25,726	0.82%
Scope 3	Waste Generated in Operations	157,776	5.01%
Scope 3	Business Travel	0	0.00%
Scope 3	Employee Commuting	0	0.00%
Scope 3	Upstream Leased Assets	0	0.00%
Scope 3	Transportation and distribution of sold products	0	0.00%
Scope 3	Processing of sold products	0	0.00%
Scope 3	Use of sold products	0	0.00%
Scope 3	End-of-life treatment of sold products	0	0.00%
Scope 3	Downstream leased assets	0	0.00%
Scope 3	Franchises	0	0.00%
Scope 3	Investments	0	0.00%
Scope 3		1,320,883	41.9%
Total		3,151,939	

Figure 7: Scope 3 Protocol Activities Emissions (BAU scenario)



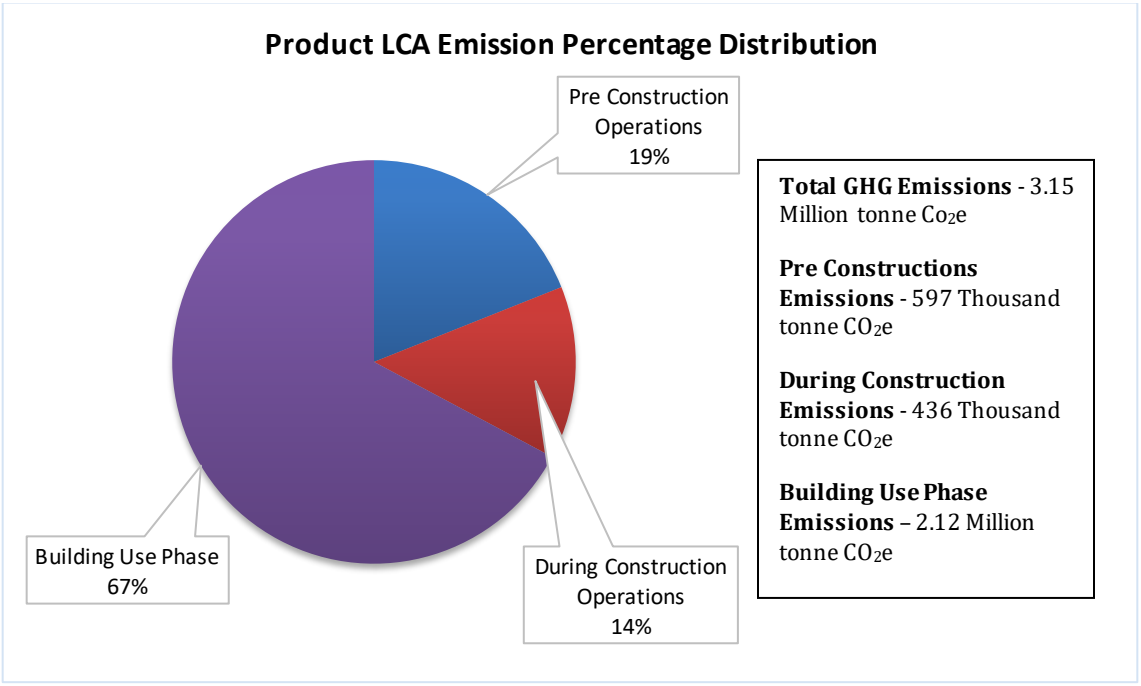
5.1.4 Product LCA Protocol Category – wise Emissions

The GHG emissions over each phase of the life cycle of the township are as follows:

Table 6: LCA GHG emissions (BAU scenario)

LCA Protocol Activities	Footprint	Percentage Emissions
	MtCO2e	%
Pre - Construction Operations	597,592	19.0%
During Construction Operations	436,336	13.8%
Post Construction Operations	0	0.00%
Building Use Phase	2,118,012	67.2%
Abandoning	0	0.00%
Total	3,151,939	

Figure 8: LCA GHG emissions (BAU scenario)



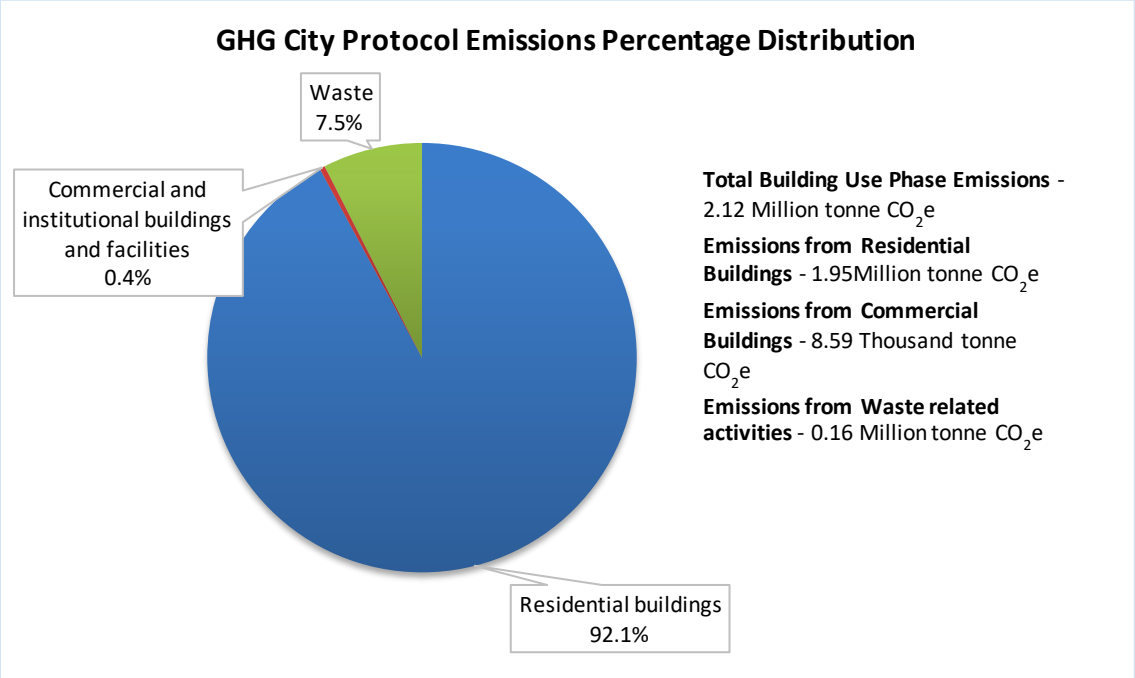
5.1.5 GHG City Protocol Category-wise Emissions

The GHG emissions according to the GHG City Protocol from the various sources are as follows:

Table 7: Emissions according to City Protocol (BAU Scenario)

City Protocol	Footprint	Percentage Emissions
	MtCO2e	%
Residential buildings	1,950,772	92.1%
Commercial and institutional buildings and facilities	8,589	0.41%
Manufacturing industries and construction	0	0.00%
Agriculture, forestry and fishing activities	0	0.00%
Non-specified sources	0	0.00%
Fugitive emissions from mining, processing, storage, and transportation of coal	0	0.00%
Fugitive emissions from oil and natural gas systems	0	0.00%
Transportation	0	0.00%
Transportation & C 3.1 Transportation	0	0.00%
Waste	158,651	7.49%
Industrial Processes and Product Uses	0	0.00%
Agriculture, Forestry and Other Land Use	0	0.00%
Total	2,118,012	

Figure 9: Emissions according to City Protocol (BAU scenario)



5.2 *Low Carbon Scenario*

5.2.1 Activity Data

The GHG inventory was calculated according to various activities which are categorized under Scope 1, Scope 2 or Scope 3. Summary of the calculations for GHG Emissions of each activity under Low Carbon scenario is shown in Table 8: Activity Data for Low Carbon Scenario.

Table 8: Activity Data for Low Carbon Scenario

Activity Type	Activity Data	Units	GHG Emission (tonne CO2e)	% of total Carbon footprint
Scope 1				
Biomas Loss	22,480,021	m2-year	27,118	0.86%
Biomas Gain	1,336,304	m2-year	-6,559	-0.29%
Fuel Use- Site Construction	1,303	kiloliters (Fuel)	3,468	0.11%
Subtotal			***24,028***	***1.07%***
Scope 2				
Electricity	1.19 billion	kwh	1,058,959	33.6%
Water	70.6 million	kiloliters	141,755	4.50%
Subtotal			***1,200,714***	***53.4%***

Scope 3				
Construction Materials	456,359	tonnes	572,916	25.5%
Logistics	9,271	kilolitres (Fuel)	24,676	1.10%
Logistics	173,371	tonne-km	11	0.00%
Waste	236,983	tonne	64,504	2.9%
Electricity T&D losses	0.36 billion	kwh	360,367	16.0%
Subtotal			***1,022,474***	***45.5%***
Total GHG Emissions			***2,247,216***	

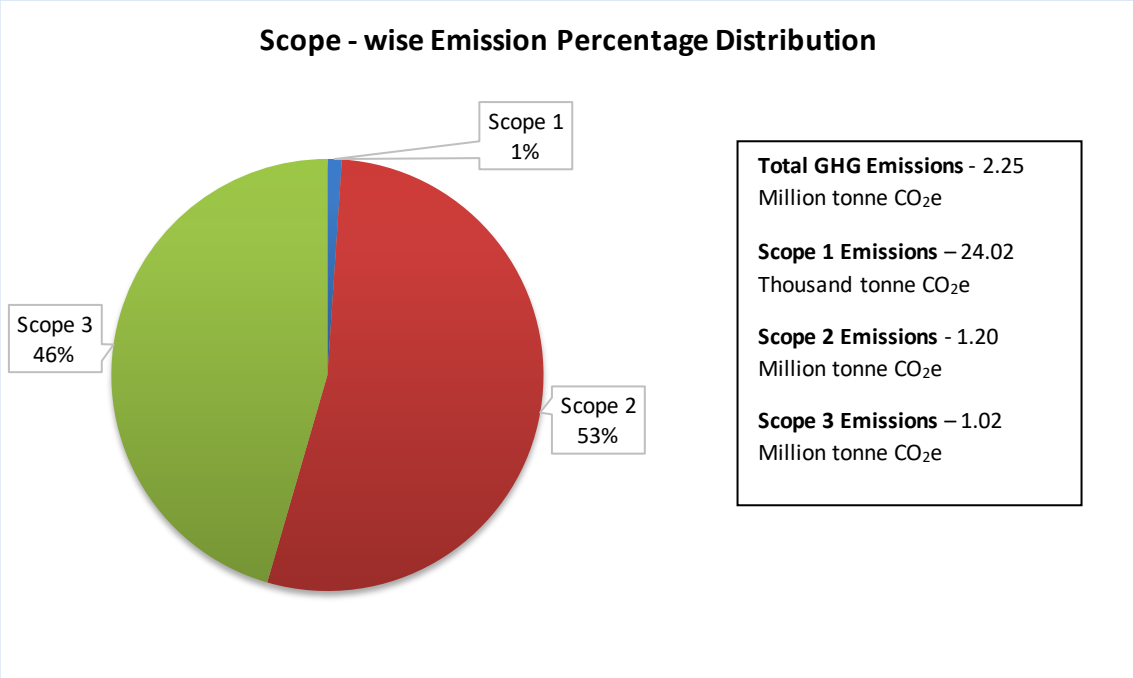
5.2.2 Corporate Standard Protocol Scope-wise Emissions

The GHG emissions after all the green measures are successfully implemented in the operations of the proposed township according to the 4 standard protocols were calculated.

Table 9: Scope-wise emissions (Low Carbon scenario)

Scopes	**Footprint**	**Percentage Emissions**
	MtCO2e	**%**
Scope 1	24,028	1.07%
Scope 2	1,200,714	53.4%
Scope 3	1,022,474	45.5%
Total	2,247,216	

Figure 10: Scope-wise emissions (Low Carbon scenario)



5.2.3 Scope 3 Protocol Category-wise Emissions

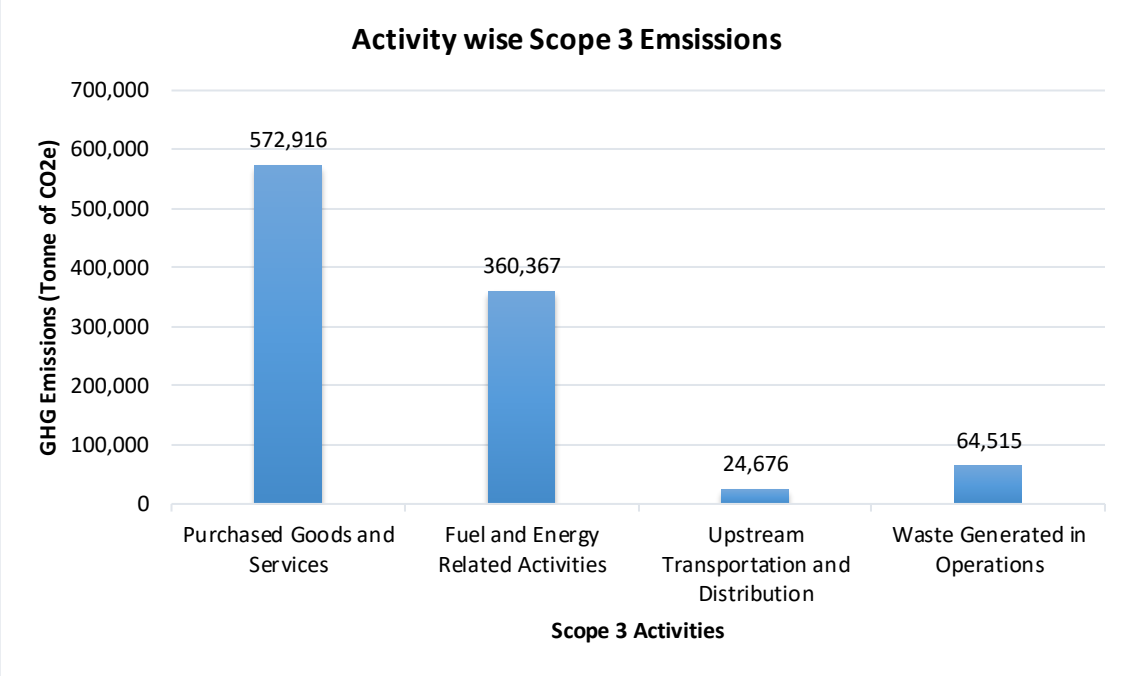
The GHG emissions for each significant category of the scope 3 GHG protocol are as follows:

Table 10: Scope 3 Protocol Activities Emissions (Low Carbon scenario)

Scopes	Scope 3 Protocol Categories	Footprint	Percentage Emissions
		MtCO2e	%
Scope 1	Biomass Gain/Loss (AFOLU)	20,560	0.91%
Scope 1	Purchased Fuel	3,468	0.15%
Scope 1		24,028	1.07%
Scope 2	Purchased Electricity	1,058,959	47.1%
Scope 2	Purchased Water	141,755	6.3%
Scope 2	Purchased Heat	0	0.00%
Scope 2		1,200,714	53.4%
Scope 3	Purchased Goods and Services	572,916	25.5%
Scope 3	Capital Goods	0	0.00%
Scope 3	Fuel and Energy Related Activities	360,367	16.0%
Scope 3	Upstream Transportation and Distribution	24,676	1.10%
Scope 3	Waste Generated in Operations	64,515	2.9%
Scope 3	Business Travel	0	0.00%
Scope 3	Employee Commuting	0	0.00%

Scope 3	Upstream Leased Assets	0	0.00%
Scope 3	Transportation and distribution of sold products	0	0.00%
Scope 3	Processing of sold products	0	0.00%
Scope 3	Use of sold products	0	0.00%
Scope 3	End-of-life treatment of sold products	0	0.00%
Scope 3	Downstream leased assets	0	0.00%
Scope 3	Franchises	0	0.00%
Scope 3	Investments	0	0.00%
Scope 3		1,022,474	45.5%
Total		2,247,216	

Figure 11: Scope 3 Protocol Activities Emissions (Low Carbon)



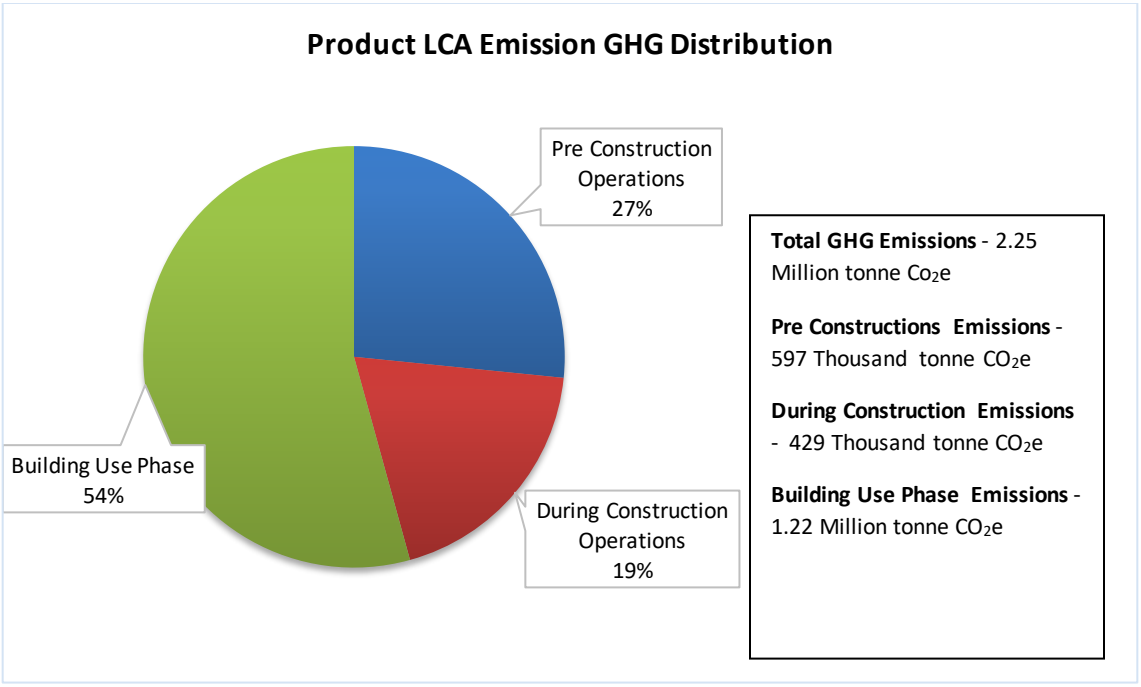
5.2.4 Product LCA Protocol Category-wise Emissions

The GHG emissions over each phase of the life cycle of the township are as follows:

Table 11: LCA GHG emissions (Low Carbon scenario)

LCA Protocol Activities	Footprint	Percentage Emissions
	MtCO2e	%
Pre Construction Operations	597,592	26.6%
During Construction Operations	429,777	19.1%
Post Construction Operations	0	0.00%
Building Use Phase	1,219,848	54.3%
Abandoning	0	0.00%
Total	2,247,216	

Figure 12:LCA GHG emissions (Low Carbon scenario)



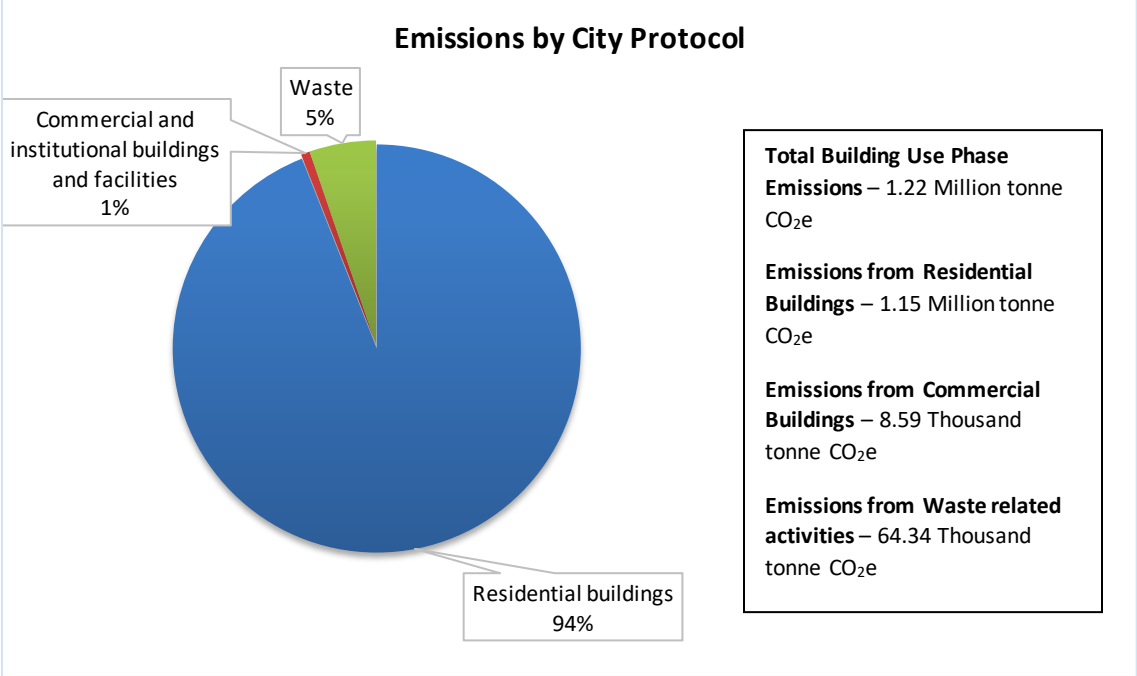
5.2.5 City Protocol Category – wise Emissions

Table 12: Emissions according to City Protocol (Low Carbon Scenario)

City Protocol	Footprint	Percentage Emissions
	MtCO2e	%
Residential buildings	1,146,919	94.0%
Commercial and institutional buildings and facilities	8,589	0.70%

Manufacturing industries and construction	0	0.00%
Agriculture, forestry and fishing activities	0	0.00%
Non-specified sources	0	0.00%
Fugitive emissions from mining, processing, storage, and transportation of coal	0	0.00%
Fugitive emissions from oil and natural gas systems	0	0.00%
Transportation	0	0.00%
Transportation & C 3.1 Transportation	0	0.00%
Waste	64,340	5.3%
Industrial Processes and Product Uses	0	0.00%
Agriculture, Forestry and Other Land Use	0	0.00%
Total	1,219,848	

Figure 13: Emissions according to City Protocol (Low Carbon Scenario)



5.3 *GHG Mitigation*

5.3.1 Scope wise Mitigation

Table 13: Scope wise Mitigation

Scopes	BAU Scenario	Low Carbon Scenario	Quantity Mitigated	Percentage Emissions

	MT CO2e	MtCO2e	MtCO2e	%
Scope 1	30,586	24,028	6,559	0.72%
Scope 2	1,800,469	1,200,714	599,755	66.3%
Scope 3	1,320,883	1,022,474	298,409	33.0%
Total	3,151,939	2,247,216	904,723	28.7% (Net Savings)

Figure 14: Scope wise Mitigation

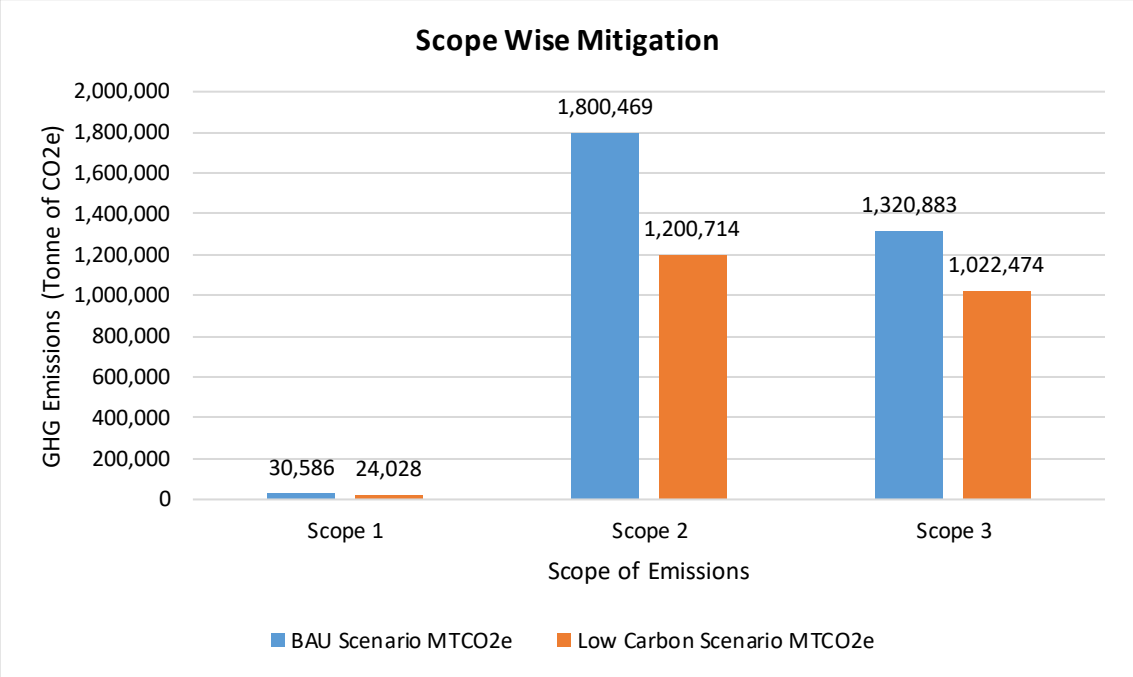
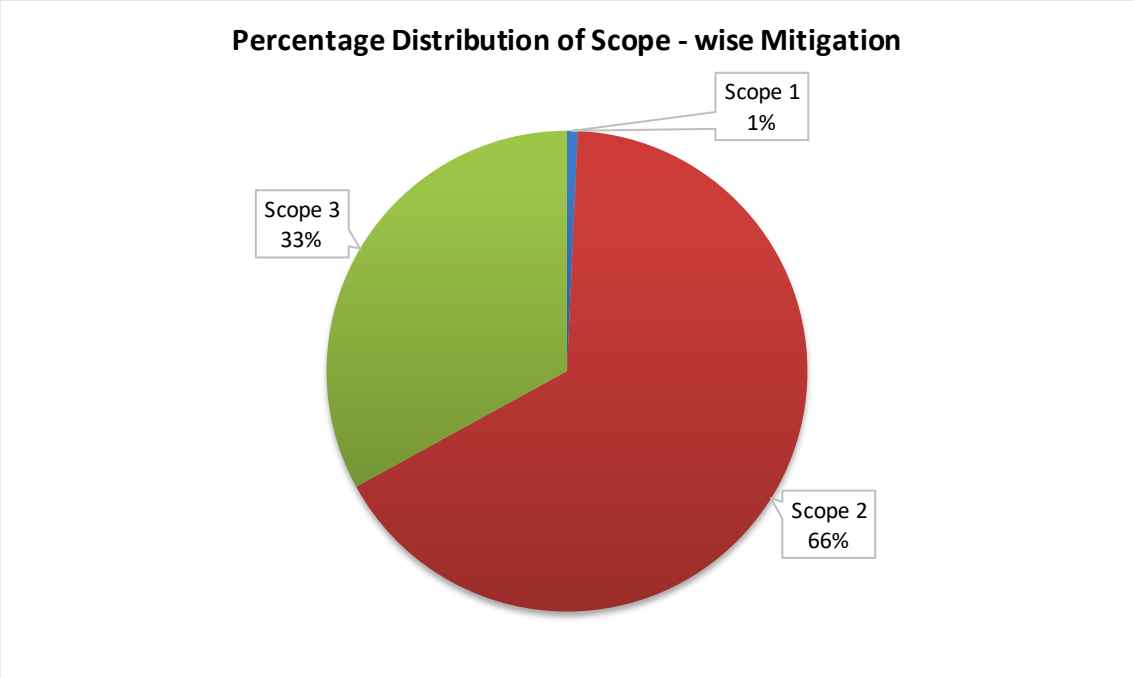


Figure 15: Percentage distribution of Scope -wise mitigation



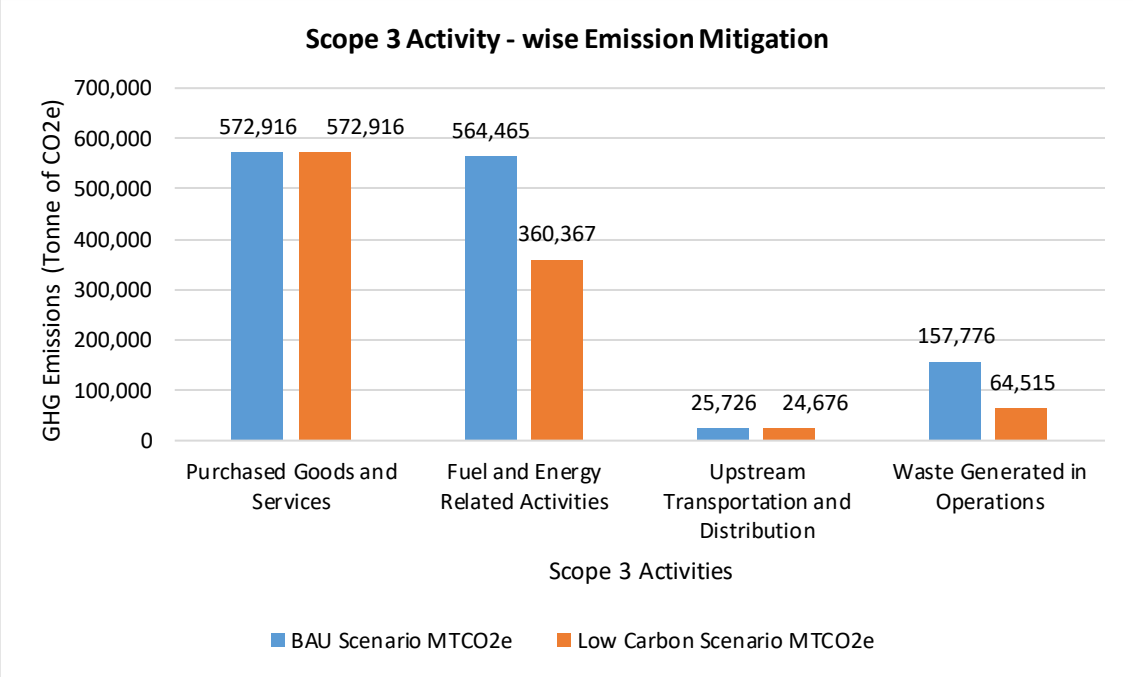
5.3.2 Scope 3 Category – wise Emission Mitigation

Table 14: Scope 3 Emission Mitigation

Scopes	Scope 3 Protocol Categories	BAU Scenario	Low Carbon Scenario	GHG Mitigation	Percentage Emissions
		MtCO2e	MtCO2e	MtCO2e	%
Scope 1	Biomass Gain/Loss (AFOLU)	27,118	20,560	6,559	0.72%
Scope 1	Purchased Fuel	3,468	3,468	0	0.00%
Scope 1		30,586	24,028	6,559	0.72%
Scope 2	Purchased Electricity	1,658,714	1,058,959	599,755	66.3%
Scope 2	Purchased Water	141,755	141,755	0	0.00%
Scope 2	Purchased Heat	0	0	0	0.00%
Scope 2		1,800,469	1,200,714	599,755	66.3%
Scope 3	Purchased Goods and Services	572,916	572,916	0	0.00%
Scope 3	Capital Goods	0	0	0	0.00%
Scope 3	Fuel and Energy Related Activities	564,465	360,367	204,098	22.6%

Scope 3	Upstream Transportation and Distribution	25,726	24,676	1,050	0.12%
Scope 3	Waste Generated in Operations	157,776	64,515	93,261	10.3%
Scope 3	Business Travel	0	0	0	0.00%
Scope 3	Employee Commuting	0	0	0	0.00%
Scope 3	Upstream Leased Assets	0	0	0	0.00%
Scope 3	Transportation and distribution of sold products	0	0	0	0.00%
Scope 3	Processing of sold products	0	0	0	0.00%
Scope 3	Use of sold products	0	0	0	0.00%
Scope 3	End-of-life treatment of sold products	0	0	0	0.00%
Scope 3	Downstream leased assets	0	0	0	0.00%
Scope 3	Franchises	0	0	0	0.00%
Scope 3	Investments	0	0	0	0.00%
Scope 3		1,320,883	1,022,474	298,409	33.0%
Total		3,151,939	2,247,216	904,723	28.7 % (Net Savings)

Figure 16: Scope 3 Emission Mitigation



5.3.3 **Product LCA Stage-wise Mitigation**

Table 15: LCA Mitigation

LCA Protocol Activities	BAU Scenario	Low Carbon Scenario	Quantity Mitigated	Percentage Emissions
	MtCO2e	MtCO2e	MtCO2e	%
Pre Construction Operations	597,592	597,592	0	0.00%
During Construction Operations	436,336	429,777	6,559	0.72%
Post Construction Operations	0	0	0	0.00%
Building Use Phase	2,118,012	1,219,848	898,164	99.3%
Abandoning	0	0	0	0.00%
Total	3,151,939	2,247,216	904,723	28.7 % (Net Savings)

Figure 17: LCA Phase – wise Emission Mitigation

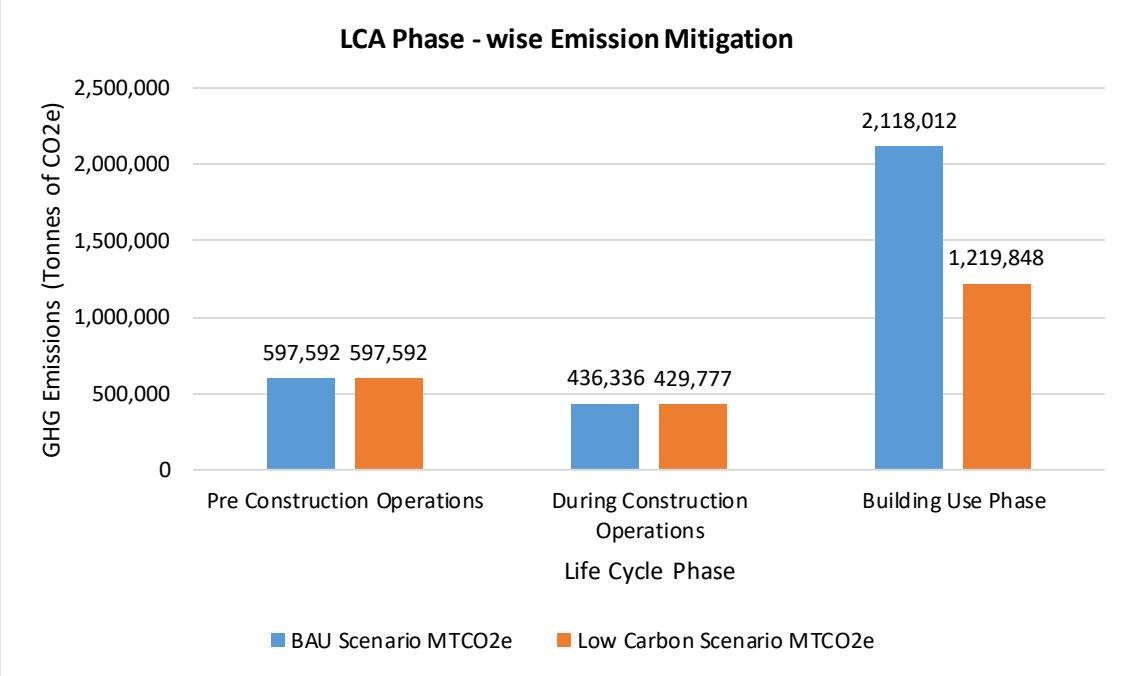
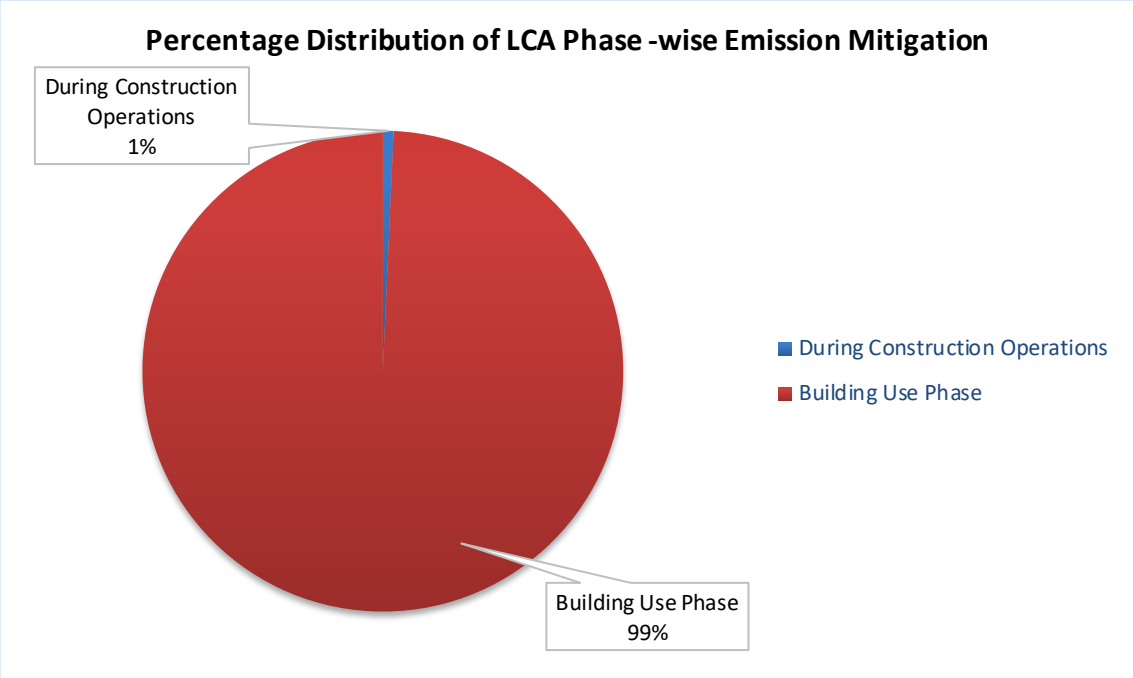


Figure 18: Percentage Distribution of LCA Phase -wise Emission Mitigation



5.3.4 City Protocol Category-wise Emission Mitigation

The GHG emissions according to the GHG City Protocol from the various sources are as follows:

Table 16: Emissions mitigation according to City Protocol

City Protocol	BAU Scenario	Low Carbon Scenario	Quantity Mitigated	Percentage Emissions
	MtCO2e	MtCO2e	MtCO2e	%
Residential buildings	1,950,772	1,146,919	803,853	89.5%
Commercial and institutional buildings and facilities	8,589	8,589	0	0.00%
Manufacturing industries and construction	0	0	0	0.00%
Agriculture, forestry and fishing activities	0	0	0	0.00%
Non-specified sources	0	0	0	0.00%
Fugitive emissions from mining, processing, storage, and transportation of coal	0	0	0	0.00%
Fugitive emissions from oil and natural gas	0	0	0	0.00%

systems				
Transportation	0	0	0	0.00%
Transportation & C 3.1 Transportation	0	0	0	0.00%
Waste	158,651	64,340	94,311	10.5%
Industrial Processes and Product Uses	0	0	0	0.00%
Agriculture, Forestry and Other Land Use	0	0	0	0.00%
Total	2,118,012	1,219,848	898,164	42.4% (Net Savings)

Figure 19: Emissions mitigation according to City Protocol

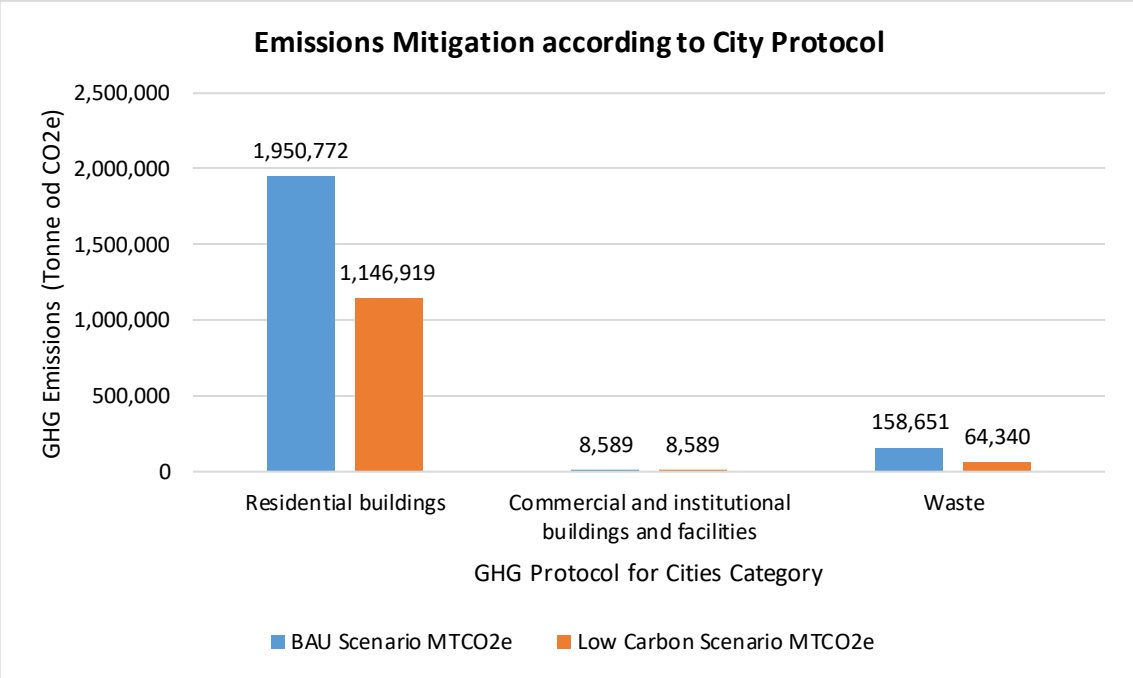
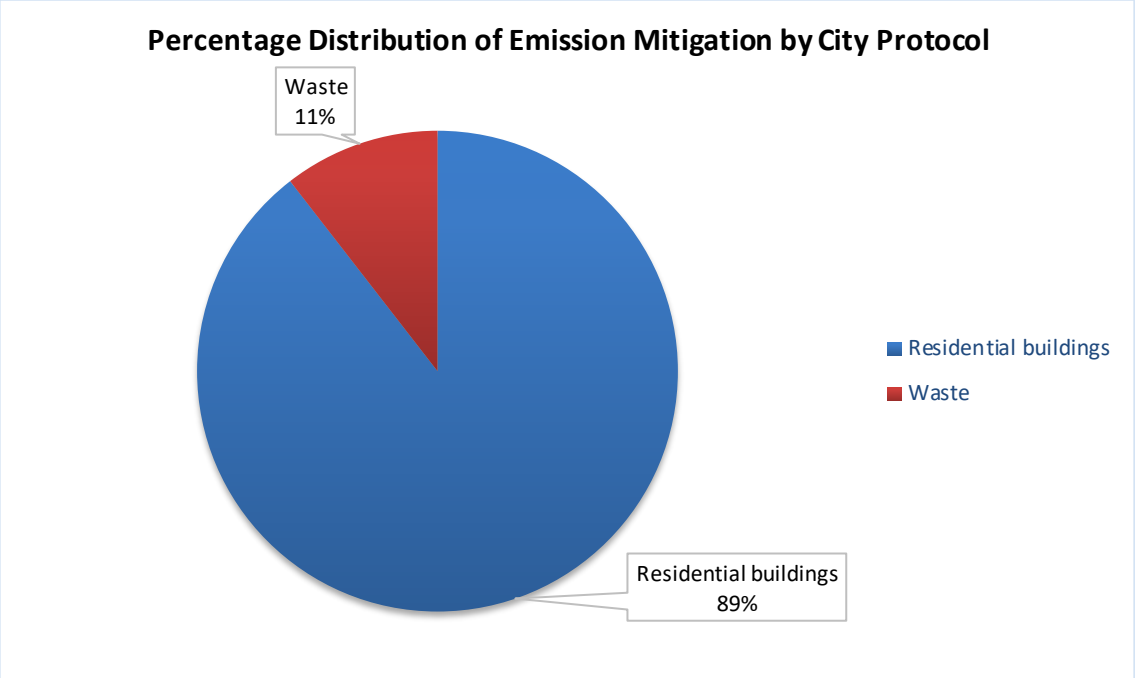


Figure 20: Percentage Distribution of Emission Mitigation by City Protocol



6. Conclusions and Recommendations

The overall carbon footprint is estimated to be 3.15 million ton CO2e over the project's lifespan (50 years) under BAU scenario, the largest contributors are Scope 2 activities which contribute 57 % to the total footprint in BAU Scenario. Followed by Scope 3 and Scope 1 activities which contributes 42% and 1% respectively to the overall footprint under BAU Scenario. With respect to life cycle protocol, Building use phase operations contributes approximately 67% to overall footprint

The low carbon interventions result in overall estimated carbon footprint of 2.24 million ton CO2e, mitigating 0.90 million ton CO2e. This results in net savings of 29%

The overarching conclusion from the carbon footprinting process was that the following positive impacts on the environment:

- Reduce **Greenhouse Gas Emissions by 18,094 metric tonnes of CO2e per year** (equivalent to planting approximately 72,378 trees every year)
- Conserve **15.1 million units of electricity every year** (enough to power 11,231 average Indian homes per year; 21,359 people per year)

The townships will irreversibly alter Land-Use Patterns in the region. Loss of shrubland from Land-Use Change is expected to reduce sequestration capacity by approximately 27,118 Metric Tonnes of CO2e over the life of the project. Plantation of trees on site post the construction phase will sequester approximately 6,558 Metric Tonnes CO2e over 50 years. This is however, only 24% of the current sequestration capacity provided by the shrubland. The net sequestration-capacity loss of 14,002 Metric Tonnes CO2e over 50 years must be reduced through high density natural afforestation methods rather than plantation-forestry methods conventionally used. It is recommended that the Township employ the Miyawaki Method of afforestation during and post construction. This rapid forest growth method works according to the principle of 'Potential Natural Vegetation' and involves planting of native specifies in high density grids of 300 trees per 100 sq.m. It is estimated that this method could sequester approximately 7,500 tonnes of CO_2 / hectare during an assumed lifespan of 25 years[8].

The township's annual electrical energy consumption is expected to be approximately 3.03 Crore kWh (units) in the BAU scenario for its 8,429 flats. This equates to approximately 3,594 kWh/flat/year. This value can be contextualized by comparing with the average annual household energy consumption in India for Urban Middle Class Home which is estimated to be approximately 1,200 kWh/home/year[9]. Thus, under BAU conditions the energy consumption from the proposed flats is approximately 3.0 times the national average. Energy efficient design and incorporation of renewable energy features are expected to greatly reduce this energy consumption by approximately 55% to 2,000 kWh/flat/year. However, this is still approximately 1.67 times the national average. The set of seven (7) energy conservation features of Reduced Window-to-Wall Ratio, Natural Ventilation, Ceiling Fans, Energy-Saving Light Bulbs, Lighting Controls for Common Areas and Outdoors, Energy Efficient Refrigerators and Clothes Washing Machines needs to be greatly augmented by integration of a suite of passive design features including use of thermal mass to reduce heat gain, insulating materials or cavity walls, appropriate shading strategies for fenestration, low-U glazing, low-E films, heat-reflective paints. Besides the passive features, it is highly recommended that solar heat gain through rooftops and walls by mitigated through inclusion of structure and radiant cooling systems within all floor and ceiling slabs. Without incorporation of efficient and sustainable cooling

[8] Based on 10 kg CO2e/year sequestration capacity per tree and 25 year lifespan, leading to 0.25 tonnes CO2e sequestration during the lifetime of a typical mid-growth stage tree.
[9] Demystifying Energy Use: From Home to a Power Plant in a Car, Energy Conservation and Commercialization (ECO-III), Satish Kumar et al., June 2010

strategies, it is unlikely that GHG emissions and energy consumption from the residential buildings will be consonant with national averages for Urban Middle Class Homes.

Finally, it is recommended that all flats be designed in a manner than enables integration of Natural Refrigerant-Based Split ACs should the flat owners choose to install an AC. These ACs will greatly reduce direct GHG emissions from HCFCs and HFCs (a conventional 2 TR split AC can lead to 0.4 tonnes of $CO2_e$ emissions per year from refrigerant leakage alone) and also indirect emissions from reduced electricity use (their average COP is 3.7 to 3.9 versus the COP of conventional BEE 5 Star Rated ACs with COPs of approximately 3.3 to 3.4). To enable residents to purchase and install these ACs, the distance between the Indoor and Outdoor Unit in the Flat Layout must be no greater than 20 feet to restrict maximum refrigerant charge per circuit to less than 365 g for a 1.5 TR AC[10].

The analysis indicates that a proactive approach towards further reducing energy consumption from anticipated indoor air conditioning, renewable energy use for hot water heating, and high-calibre natural afforestation methods can further enhance the GHG emission mitigation from the estimated 28.7% emissions reductions (from 3.15 to 2.25 Million Tonnes CO_2e over 50 years, i.e. 0.9 Million Tonnes CO_2e mitigation over 50 years) that have been planned for.

It is recommended that the builder use this GHG emissions baselining exercise as a milestone to set GHG reduction and mitigation targets to reduce the GHG Intensity of its annual turnover by 20-25% by 2020 and to 33-35% by 2030 in alignment with Govt. of India's commitment to UNFCCC's COP-21.

[10] ISO 5149 Standard

7. Annexures

7.1 *Annexure I*

List of assumptions made for carrying out the GHG emission calculations

1. Materials procured distance - 400 km
2. Operations days - 365 days/year
3. Operation Hours - 10 hours/day
4. Procurement of tanker water distance - 80 km Round trip
5. Fuel efficiency of transportation vehicles - 2.25 km/litre
6. Pay load capacity of transportation vehicles - 18 tonnes
7. Waste disposal from Township is done to waste recycling centres/municipal landfills

7.2 *Annexure II*

Energy Modelling Calculations

	1 BHK	2 BHK	3 BHK C	3 BHK R	3.5 BHK	4.5 BHK	Shops
Energy consumption (kWh/flat) – BAU Scenario	218	247	416	555	682	897	300
Energy consumption (kWh/flat) - Efficient Scenario	135.7	154.3	244.5	349.7	426.3	577.4	300

Number of flats							
	1BHK (P+4)	2BHK Comfort (P+4)	1BHK (P+10)	2BHK Compact (P+12)	2BHK Comfort (P+12)	Total	No of Shops
Sector 1	336	150	0	0	0	486	
Sector 2	0	0	330	201	180	711	
Sector 3	0	0	275	260	258	793	
Sector 4	0	0	275	195	172	642	
Sector 5	0	0	330	248	125	703	
Sector 6	0	0	220	284	188	692	
Sector 7	0	0	330	213	188	731	
Sector 8	0	0	0	0	94	94	
Sector 9	0	0	78	130	86	294	
Sector 10	0	0	330	213	188	731	
Sector 11	0	0	639	213	188	1040	
Sector 12	0	0	550	195	172	917	
Sector 13	0	0	220	195	180	595	
Total	336	150	3577	2347	2019	8429	40
BAU Scenario							
Energy Consumption (kWh/month)	75684	39862.5	785330.35	618434.5	544221.45	2528700	12000

Energy Consumption (kWh/year)	908208	478350	9423964.2	7421214	6530657.4	30344400	144000
Energy Consumption 50 years (kWh)	45410400	23917500	471198210	371060700	326532870	1517220000	7200000
Efficiency Scenario							
Energy Consumption (kWh/month)	54129.6	22860	531899.9	424572.3	372101.7	1405563.5	
Energy Consumption (kWh/year)	649555.2	274320	6382798.8	5094867.6	4465220.4	16866762	
Energy Consumption 50 years (kWh)	32477760	13716000	319139940	254743380	223261020	843338100	

7.3 *Annexure III*

List of Emission Factors used for GHG inventorying:

Category	***Emission Factor***	***Units***	***Source***
Scope 1			
Biomass Gain	-4.91	kg CO2e/m2/year	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 4: Forest Land, for Biomass Gain, Plantation, Asia Productive plantations , Eucalyptus camaldulensis, Asia, Tier 1, Carbon Stock Change Emissions
Biomass Loss	1.21	kg CO2e/m2/year	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use, Chapter 4: Forest Land,Tropical shrubland, ≤20 y, Asia (continental), Tier 1, Carbon Stock Change Emissions
Diesel	2.66	kg CO2e / litre	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 2: Stationary Combustion
Scope 2			
Purchased Electricity	0.89	kg CO2e/kwh	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 2: Stationary Combustion, Energy Statistics 2011 - Central Statistics Office Ministry Of Statistics And Programme Implementation Government Of India, and CEA Reports
Municipal Water	0.002	kg CO2e / litre	IIM-A, Internal research cBalance - Electricity consumption of upwelling - CGH Earth

Tanker Water	0.0055	kg CO2e / litre	Fuel Efficiency - The Impact of India's Diesel Price Reforms on the Trucking Industry- June 2013, pg 11 , URL link - https://www.iisd.org/gsi/sites/default/files/ffs_india_irade_trucking.pdf; Electricity consumption of upwelling - CGH Earth , cBalance
Scope 3			
Aerobic Composting	0.27	kg CO2e / kg	2006 IPCC Guidelines Vol - 5 Waste, Chapter 3 - Solid Waste Disposal
Aluminum - semi-finished & finished products	25.31	kg CO2e / kg	2006 IPCC Guidelines Vol - 3 Industrial Products, Chapter 4- Metal Industry, Life Cycle Assessment Of Aluminium: Inventory Data For The Primary Aluminium Industry Year 2005 Update, International Aluminium Institute, International Aluminium Institute Results of the 2009 Anode Effect Survey Report on the Aluminium Industry's Global Perfluorocarbon Gases Emissions Reduction Programme
Cement	0.86	kg CO2e / kg	2006 IPCC Guidelines Vol 3 - Industrial Products, Chapter 2 - Mineral Industry - Proceedings of the Workshop on Uncertainty Reduction in Greenhouse Gas Inventories, Ministry of Environment and Forests, Government of India , Carbonomist GHG Inventory Modelling
Ceramic Tiles	1.99	kg CO2e / kg	Comparative Analysis of Embodied Energy Rates for Walling Elements in India, Table 1 Embodied energy values (EEV) of building materials, IE (I) Journal—AR, Vol 84, October 2003,Emissions Inventory of India
Glass - Float Glass/Toughened Glass	3.07	kg CO2e / kg	2006 IPCC Guidelines Vol - 2 Energy, Chapter 3 - Mobile Combustion

Granite stone	1.52	kg CO2e / kg	Comparative Analysis of Embodied Energy Rates for Walling Elements in India, Table 1 Embodied energy values (EEV) of building materials, IE (I) Journal—AR, Vol 84, October 2003, Emissions Inventory of India
Kota stone	0.07	kg CO2e / kg	Comparative Analysis of Embodied Energy Rates for Walling Elements in India, Table 1 Embodied energy values (EEV) of building materials, IE (I) Journal—AR, Vol 84, October 2003, Emissions Inventory of India
Plywood	2.08	kg CO2e / kg	Comparative Analysis of Embodied Energy Rates for Walling Elements in India, Table 1 Embodied energy values (EEV) of building materials, IE (I) Journal—AR, Vol 84, October 2003, Emissions Inventory of India
River Sand	0.02	kg CO2e / kg	Comparative Analysis of Embodied Energy Rates for Walling Elements in India, Table 1 Embodied energy values (EEV) of building materials, IE (I) Journal—AR, Vol 84, October 2003, Emissions Inventory of India
Steel Bar/Rod & Other finished steel products	3.18	kg CO2e / kg	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 3, Chapter 4: Metal Industry Emissions, Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance Direct Emissions From Iron & Steel Production
Stone Chips/Ravali	0.22	kg CO2e / kg	Comparative Analysis of Embodied Energy Rates for Walling Elements in India, Table 1 Embodied energy values (EEV) of building materials, IE (I) Journal—AR, Vol 84, October 2003, Emissions Inventory of India
T & D Losses	0.3	kg CO2e/kwh	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 2: Stationary Combustion, Energy Statistics 2011 - Central Statistics Office Ministry Of Statistics And Programme Implementation Government Of India, and CEA Reports

Transported Material	0.00006568	kg CO2e/kg-km	The Impact of India's Diesel Price Reforms on the Trucking Industry- June 2013, pg 11 , URL link - https://www.iisd.org/gsi/sites/default/files/ffs_india_irade_trucking.pdf
Unmanaged Landfill	0.66	kg CO2e / kg	2006 IPCC Guidelines Vol - 5 Waste, Chapter 3 - Solid Waste Disposal

7.4 *Annexure IV*

Interaction of the indicators from Scope 3 GHG Protocol, LCA GHG Protocol and GHG Protocol for cities used for categorizing the data and resulting GHG emissions.

Table A - Scope 3 Protocol + Corporate Accounting Std		
Upstream Scope 3 Emissions	**Scope 1 & Scope 2 Emissions**	**Downstream Scope 3 Emissions**
Purchased Goods and Services	Purchased Fuel	Transportation and distribution of sold products
Capital Goods	Purchased Electricity	Processing of sold products
Fuel and Energy Related Activities	Purchased Water	Use of sold products
Upstream Transportation and Distribution	Purchased Heat	End-of-life treatment of sold products
Waste Generated in Operations		Downstream leased assets
Business Travel		Franchises
Employee Commuting		Investments
Upstream Leased Assets		

Table B - Product LCA				
Material Acquisition and Pre-Processing	**Production**	**Distribution & Storage**	**Use**	**End-of-Life**
Pre-Construction Operations	During Construction Operations	Post Construction Operations	Building Use Phase	Abandoning
Construction Equipment Procurement	*Excavation*	*Waste Removal*	*Operations*	*Demolishing*
Construction Material & Chemical Procurement	*Construction*	*Waste Recycling*	*Waste Management*	*Waste Removal*
Fuel Procurement	*Maintenance*	*Transfer of Construction Equipment*		*Waste Recycling*

Table C - GHG Protocol for cities		
Upstream Scope 3 Emissions	**Scope 1 & Scope 2 Emissions**	**Downstream Scope 3 Emissions**
Stationary Energy	Stationary Energy	Transportation
Residential buildings	Residential buildings	On-road transportation
Emissions from transmission and distribution losses from grid-supplied energy consumption	Emissions from fuel combustion within the city boundary	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption

Commercial and institutional buildings and facilities	Emissions from grid-supplied energy consumed within the city boundary	Railways
Emissions from transmission and distribution losses from grid-supplied energy consumption	Commercial and institutional buildings and facilities	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption
Manufacturing industries and construction	Emissions from fuel combustion within the city boundary	Waterborne navigation
Emissions from transmission and distribution losses from grid-supplied energy consumption	Emissions from grid-supplied energy consumed within the city boundary	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption
Energy industries	Manufacturing industries and construction	Aviation
Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	Emissions from fuel combustion within the city boundary	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption
Agriculture, forestry and fishing activities	Emissions from grid-supplied energy consumed within the city boundary	Waste
Emissions from transmission and distribution losses from grid-supplied energy consumption	Agriculture, forestry and fishing activities	Solid waste disposal
Non-specified sources	Emissions from fuel combustion within the city boundary	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary
Emissions from transmission and distribution losses from grid-supplied energy	Emissions from grid-supplied energy consumed within the city boundary	Biological treatment of waste

consumption		
Transportation	Non-specified sources	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary
On-road transportation	Emissions from fuel combustion within the city boundary	Incineration and open burning
Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Emissions from grid-supplied energy consumed within the city boundary	Emissions from solid waste generated within the city boundary but treated outside of the city boundary
Railways	Fugitive emissions from mining, processing, storage, and transportation of coal	Wastewater treatment and discharge
Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Emissions from fugitive emissions within the city boundary	Emissions from wastewater generated within the city boundary but treated outside of the city boundary
Waterborne navigation	Fugitive emissions from oil and natural gas systems	Other Scope 3 Emissions
Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Emissions from fugitive emissions within the city boundary	
Aviation	Transportation	
Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	On-road transportation	

	Emissions from fuel combustion on-road transportation occurring within the city boundary	
	Railways	
	Emissions from fuel combustion for railway transportation occurring within the city boundary	
	Waterborne navigation	
	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	
	Aviation	
	Emissions from fuel combustion for aviation occurring within the city boundary	
	Off-road transportation	
	Emissions from fuel combustion for off-road transportation occurring within the city boundary	
	Waste	
	Solid Waste Disposal	
	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	
	Biological treatment of waste	
	Emissions from solid waste generated within the city boundary that is treated biologically	

	within the city boundary	
	Incineration and open burning	
	Emissions from solid waste generated and treated within the city boundary	
	Wastewater treatment and discharge	
	Emissions from wastewater generated and treated within the city boundary	
	Industrial Processes and Product Uses	
	Emissions from industrial processes occurring within the city boundary	
	Agriculture, Forestry and Other Land Use	
	Emissions from livestock within the city boundary	
	Emissions from land within the city boundary	
	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	