CARBONIS – CARBON EMISSION OPTIMIZATION USING LINEAR PROGRAMMING

Magenthirarajah Vithursan

(IT19033174)

BSc (Hons) in Information Technology

Specialising in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

September 2022

CARBONIS – CARBON EMISSION OPTIMIZATION USING LINEAR PROGRAMMING

Magenthirarajah Vithursan

(IT19033174)

BSc (Hons) in Information Technology

Specialising in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

September 2022

Declaration

I declare that this is my own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to Sri Lanka Institute of Information Technology, the nonexclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Name	Student ID	Signature
Vithursan .M	IT19033174	

The supervisors should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

---------- ----------

Signature of the supervisor: Date:

Abstract

Global carbon emission reduction is required because human activities generate significant quantities of greenhouse gases, which cause climate change. As a response, nations across the globe have created policies and agreements to limit the increase of greenhouse gas emissions. Governments assigned each organization a carbon emission cap, sometimes known as a carbon credit. Every organization must reduce its carbon footprint. Despite the fact that this is a crucial duty for every organization, it is not always possible to investigate alternate sustainable options. There are numerous emission sources within an organization that can be eliminated in order to reach the desired emission reduction goal. Organizations aim to maintain emissions below carbon credits. To address these difficulties, a carbon neutrality management system is required to collect the usage restrictions of several emission sources. Using optimization methods, an optimal minimal solution will be found for these restrictions and the emission limit. This can be modified by the business analyst according to their evolving needs. When the optimal carbon emission solution is established, the solution's maximum emission value for many emission sources will be set as maximum thresholds, and alarms will be sent if these values are exceeded. Organizations can sustain carbon emissions without exceeding the carbon credit by determining the appropriate minimum emission values for each emission source. Reduced carbon emissions lessen the consequences of global climate change, promote public health, stimulate the global economy, and preserve biodiversity.

Key words – carbon emissions, carbon credit, emission constraints, emission sources, optimization

Acknowledgement

First and foremost, it is a genuine pleasure to express my deep sense of gratitude to my Research Supervisors, Ms. Anjali Gamage and Ms. Sanjeevi Chandrasiri for her fullest support, dedication, enthusiasm, and overwhelming desire his expressed throughout the project to make this research a success. I gratefully acknowledge his patience at the time of long piece of writing this report.

My sincere thanks go to seniors who helped to done this research well.

Finally, Thanks for each and every one who support me in various way to convert my project to successful project.

Contents

List of Figures

List of Tables

List of Abbreviations

CO2	Carbon dioxide
ML	Machine learning
CSV	Comma Separated Values
SVM	Support vector Machine
DL	Deep learning
CNC	Carbon Neutral Cities
GHC	Greenhouse gases
CDR	Carbon dioxide removal
GCC	Global climate change
CMH	Carbon management hierarchy
INCAM	Integrated carbon accounting and mitigation
CAC	Carbon Accounting Centre
CEI	Carbon emission indicators
UK	United Kingdom
BA	Business analyst
API	Application programming interface

1. INTRODUCTION

Climate change is the greatest environmental hazard to mankind and the earth in the 21st century. Emissions of greenhouse gases caused by human activity around the world are one of the primary contributors to the rise in the frequency of climate-related disasters. Cumulative carbon dioxide (CO2) emissions exhibited a linear association with cumulative temperature rise since the pre-industrial stage, and this accounts for approximately 80% of the total human greenhouse gases. As a result, the foundation and scientific basis for the majority of the policies and target setting about emission reduction is data on carbon emissions that are accurate and reliable. At this time, China has made it abundantly apparent that it intends to achieve the ambitious objective of reaching the peak of carbon emissions by the year 2030 and reaching carbon neutrality by the year 2060. For the purpose of achieving more accurate carbon emission monitoring, the development of a finer-grained spatiotemporal carbon emission database is urgently required. This is necessary for the continual implementation and the iterative improvement of emission reduction programs. Near-real-time carbon emission monitoring is not only a huge governmental requirement but also a scientific question at the frontier of this discipline.

Because of their high market visibility, interaction with the public, and impact on the economy, businesses and organizations pose a significant threat to the environment in the form of carbon emissions. Any quantity of carbon dioxide (CO2) that is expelled into the atmosphere as a direct result of a business's operations is required to be compensated for by the removal of an equivalent amount. In a world that is rapidly expanding, the intensity and density of their population typically results in a high number of individuals. The primary objective of this study is to achieve carbon neutrality by emitting a quantity of carbon dioxide that has been carefully and effectively optimized. It is imperative that prompt and sustainable efforts be taken in order to reduce global emissions of greenhouse gases (GHC) by 45% by the year 2030 and get them down to zero by the year 2050. This is the only way to bring the amount under control. These days, developed nations and cities are setting up long-term activities to attain Carbon Neutral Cities (CNC) by

enhancing their infrastructure, establishing good management, making better use of their operations, and shifting their habilitations towards greener urban life. In the meantime, significant corporate institutions such as labor corporations are also classified as "little cities" due to their enormous size, diverse population, and the consistent dense activities and operations that take place on their premises. Because of advancements in internet technology and digital processing, we now have the ability to generate more actionable information in a way that is more innovative for the purpose of optimizing carbon. It is also possible to think of a sustainable business as a higher organization that works toward the amelioration of the negative environmental, financial, and social effects that are caused by the utilization of the company's resources. Companies are the best research organizations because they provide the opportunity to experiment with and exhibit sustainable methods of carbon emission and optimization. An approach that is carbon neutral can be accomplished by first organizing, then calculating the greenhouse carbon emission of the organization, and then developing a strategy to reduce the carbon emission of the organization. After that, it is necessary to accumulate carbon credits in order to effectively manage the lingering emissions. Emissions will be minimized to the greatest extent practicable, making carbon neutrality a real possibility. The GHG protocol is the most prevalent type of analysis technique that is used to determine the carbon footprint. This is a standard tool for calculating and reporting the direct and indirect greenhouse gas emissions that are associated with an institution. When other greenhouse gases are factored into the computation, a carbon footprint is often reported in kilograms or tons of CO2 equivalents. The quickest and easiest method for business organizations to calculate the amount of carbon dioxide emissions caused by travel is to first determine the total distance traveled using a variety of transportation emission sources listed on travel order forms and then convert this distance into tons of equivalent CO2 using the appropriate conversion factors. Real-time optimization, when applied within the scope of carbon neutrality research, has the potential to produce and maximize the co-benefits that result from various industrial emission initiatives. However, the fundamental value of real-time carbon emission optimization has not yet been thoroughly explored. This is because there is a lack of ideational views on how such an ability might enable optimization through a vision of carbon neutrality [13], which is preventing

comprehensive exploration of the value. The overarching purpose has been met in that it has been followed in terms of inquiring into the following research topics. This will help advance and highlight the results of this standard investigation. (1) The measurement and computing of the carbon footprint, which includes the use of algorithms, techniques for the measurement and computation of emission criteria, validation reviews, and limitations. (2) Compute and evaluate the practicality and effectiveness of various approaches for relief while working within the context of a business or other corporate organization. Because of the work done in this research, researchers in the future will be able to address issues on a strategic and policy level. This research, for example, will assist in the identification of various technological, social, and economic barriers in the implementation of carbon emission optimization, and it will describe obstacles that stand in the way of the development of sustainable organizations that are friendly to the environment. Therefore, one of the primary objectives of this research is to formulate the concept of real-time carbon neutrality management and optimization and its paramount role in carbon neutral organizations. Another objective of this research is to discuss carbon emission management and optimization that has been effectively implemented by the business organization on the mission of making the organization carbon neutral and sustainable within a few years. This article sheds light on how a corporate organization in our country might compute the carbon footprint and compare it with a small number of default standard emission limitations.

1.1. Background & Literature Survey

1.1.1. Background

Since the 19th century, the amount of greenhouse gases (GHG) emitted into the atmosphere has steadily increased [1]. The buildup of greenhouse gases contributes to an overall increase in temperature. Human activities have been responsible for almost all of the rise in the concentration of greenhouse gases in the atmosphere during the past several decades. The most significant contributor to global warming caused by human activity is the combustion of fossil fuels for the generation of electricity and heat, as well as for transportation. The emission of greenhouse gases into the atmosphere as a result of human activity is a contributor to climate change (GHG).

At this time, governments all over the world are enforcing a variety of restrictions to control the emissions of greenhouse gases. As a direct consequence of this, businesses are required by their respective governments to monitor and report their greenhouse gas emissions. In addition, in order for companies to achieve carbon neutrality, they will need to limit their emissions to the maximum permitted level (Carbon credit).

The non-traditional threat that climate change poses to global security has emerged as a result of increased carbon emissions [2]. According to the Greenhouse Gas Bulletin (GHG Bulletin) that was published by the World Meteorological Organization in the year 2020, the steady rise in the concentration of GHG in the atmosphere has developed into a pattern that will continue indefinitely. In order to ensure that the necessary ecological goals are met within the allotted time frame, stringent and effective measures are required to be put into place. If the currently implemented limits are seen as insufficient in light of the most recent projections, then additional emission regulations can be written into law. This could result in extremely large payments due to the fact that emission regulations were not met. As a consequence of this, businesses need to give serious consideration to the emissions of greenhouse gases caused by transportation.

Many companies across a wide range of industries have come to the realization that they must take action to combat climate change if they wish to continue existing in and expanding their operations within complex and ever-shifting commercial economies. As the demand from various stakeholders continues to increase, the top executives of many different firms are increasingly employing a variety of tactics to reduce their carbon emissions. However, the degree to which companies recognize the importance of climate change and carbon management as a central tenet of their business models is not well understood and is a subject of considerable confusion.

The use of a natural language processing system in carbon neutrality management and optimization is one approach that aims to solve these problems. Using this real-time system, we will investigate several strategies to improve the efficiency of carbon emission transfers between different industrial sectors. This method is offered to optimize carbon emission transfer systems across a variety of industries with the intention of achieving the twin objectives of lowering carbon emissions and fostering economic growth. The quantity of emissions of greenhouse gases can be determined with the help of this carbon computation system. In addition to that, it considers the management of the equipment that is utilized for waste disposal. It is helpful to highlight where better carbon reductions can be made on certain emission sources when using this tool. In addition, it contributes to the total emissions and helps quantify the savings with regard to carbon emissions. Utilizing Optimization Algorithms, determine the solution that is ideal in light of the emission source limitations that have been provided, and send a warning about any violations of the optimal solution.

1.1.2. Literature review

In this particular piece of work [1], They investigated the varied contributions made by direct and underlying drivers of emissions in 206 different countries and territories during the course of the time period spanning 1960–2018. We utilized a dynamic panel estimate method that takes into consideration cross-sectional dependence, diverse parameters across nations, and dynamic correlated effects. This is a requirement for consumption- and

pollution-based socioeconomic models. In this article, a global accounting of economic policy and debt, population structure, density and urbanization, as well as environmental-related aggregate data are provided in the form of a carbon emission function. The empirical findings reveal that the overarching influence of the immediate increase in economic development, population dynamics, and energy use stimulates global emissions at the national, urban, and household levels across all countries and territories. It was discovered that industrialization and trade contribute to an increase in global pollution levels as a result of the influence of a carbonized and energy-intensive economic structure in a great number of developing and established economies. Since urbanization, urban income growth, and urban energy consumption are interrelated, the establishment of urban-related policy interventions has a good chance of mitigating the negative impact that the trio has on the environmental sustainability. The threefold effect of economic development—the exploitation of natural resources, production, and consumption—drives up environmental pollution, which in turn necessitates a structural shift away from a carbonized economy and toward a decarbonized one. The intricate connection underlines the importance of diversifying the energy mix by include clean and renewable energy sources, switching to fossil fuels, and current technologies such as carbon capture and storage to enhance energy efficiency and decrease emission intensities.

In this study [2] , the entropy weight method is applied in order to conduct a quantitative analysis of the relationship between the driving factors of carbon emission of energy structure and industrial structure and the result factors of carbon emission of energy consumption. Following this, the grey prediction model that is based on the optimization of carbon emission is developed. The law of evolution can be summarized by looking at the relationship that exists between the elements that drive evolution and the factors that determine its results. At long last, an objective analysis of the benefits and drawbacks of the model has been performed, and the results have been summed up. At the same time, the model is able to offer credible inferences regarding the pollution caused by a variety of other types of damaging gases.

The challenges that China is having with its carbon dioxide emissions and absorption are not caused by a single factor. On the other hand, it is a problem that spans multiple fields

of study and involves a number of different variables. First, a predictive and optimization model of the driving variables on carbon dioxide absorption and emission is developed. Next, the influencing factors and the degree to which carbon dioxide is present in the atmosphere are investigated from a variety of points of view.

Although the algorithm model's primary emphasis is on stochastic issues, it is founded on the findings of the assessment, and both the evaluation and the optimization processes take into account the impact on society and the environment. Although this model is unable to fully explain all of these factors, it does make use of a representative cross-section of the data that is already available in order to demonstrate the current state of affairs regarding carbon dioxide issues in China. Additionally, it elucidates both the trend of carbon dioxide before the intervention and the trend of carbon dioxide after the intervention. By strengthening the link between carbon dioxide emissions and absorption, the model demonstrates that it is conceivable for China to achieve "zero emissions" around the year 2060. Even a small modification in anthropogenic emissions has the potential to drastically alter the results.

In this paper [3], we consider a supply chain management of the automobile part manufacturing industry with suppliers to optimize the production quantity with multiple objectives, i.e., minimizing the total cost of production including minimum amount lubrication is a first objective, reduction of the carbon footprint is a second objective, and minimizing the cost of energy considering renewable energy is a third objective. These three objectives are listed in this order: minimizing the total cost of production, minimizing the cost of energy, and minimizing the cost of renewable energy This study takes into consideration a scenario in which providers monitor and control the quality of defective items as part of an outsourcing operation.

The suggested mathematical model, which considers sustainable suppliers, is solved using a technique called weighted goal programming. A sensitivity analysis of the model is carried out for each of the possible outcomes with regard to the usage of energy. The proof that successful pragmatic application has been achieved in the automotive industry is the optimal result of minimizing both production costs and carbon emissions. The findings

validate the model to the extent that it can offer the basis for sustainability in supply chain environments taking into consideration manufacturers and suppliers.

This paper present [4], the first consistent, large-scale, and global assessment of three-scope greenhouse gas inventories for all 79 members of the C40 Cities Climate Leadership Group using a novel method for creating city-level input–output tables. This assessment was made possible by using a novel method for creating city-level input–output tables. These inventories include all greenhouse gas emissions that take place outside of the city boundary as a direct result of activities that take place inside the city. This includes emissions that come from sources that are physically located within the city limits (Scope 1), emissions that take place as a direct result of using grid-supplied electricity, heat, steam, and/or cooling (Scope 2), and any other GHG emissions (Scope 3). According to the findings of this paper, the 79 cities that make up the C40 group under-report 4% of the annual global GHG emissions that come from six key infrastructure-related transboundary sources (73%) and from service-related sectors (27%). This occurs because they only account for territorial emissions and do not use Scope 3. In contrast, if solely consumption-based emissions were taken into account, the C40 cities would fall short of the mitigation objective for 41% of the emissions produced inside their territorial boundaries. In this paper, we argue that cities should expand their GHG inventories by including full Scope 3 data in addition to Scopes 1 and 2, and should develop plans for low-carbon consumption in addition to the existing climate change strategy that is centered on infrastructure.

The global stock take is scheduled to taking place in 2023 and will evaluate the joint efforts of the countries. This paper [5], shows that the implementation of current policies will leave a median emission gap of 22.4 to 28.2 GtCO2eq by 2030 with the optimal pathways to implement the well below 2 °C and 1.5 °C Paris goals. The research for this paper was based on a public policy database and a multi-model scenario analysis. This deficit would be minimized by a third if the Nationally Determined Contributions were completely implemented. It was observed that the countries that were analyzed either did not reach their pledged contributions with the policies that were implemented (an

implementation gap) or had an ambition gap with optimal routes towards much below 2 degrees Celsius. This finding was quite interesting. This demonstrates that all countries would need to speed up the implementation of policies for renewable technology, while improvements in efficiency are particularly crucial in developing countries and countries that are dependent on fossil fuels.

As respects accounting difficulties, the paper discusses [6], the complications that are involved with the value of pollution allowances and their identification as assets (and the liabilities that occur if corporations pollute beyond permissible levels) (and the liabilities that arise if companies pollute beyond allowed levels). A more in-depth investigation of the dangers and ambiguities that are brought on by GCC kicks off a conversation over the non-financial accounting and reporting of carbon. Reporting on matters other than finances is essential in order to provide the conditions for democratic accountability in an environment marked by uncertainty. The concern about the impact of anthropogenically induced global climate change (GCC) and the assumption that GCC raises issues of significance with respect to the accountability of firms to stakeholders for financial and non-financial performance served as the impetus for the creation of this special debating forum. The purpose of the forum is to discuss the implications of GCC for firm accountability to stakeholders for financial and non-financial performance. One manifestation of the various ways in which governments and supranational organizations have attempted to respond to GCC is the formation of markets in which carbon may be exchanged. This is only one of the many ways in which this has occurred. Carbon markets have the impact of putting a price on what was until very recently free and this change is likely to have financial ramifications for firms in the longer term. The purpose of this paper is to provide a scientific and policy introduction to GCC so that the accounting implications of carbon markets can be understood in their proper perspective.

According to the findings of this study [7], all of the world's regions are equipped with the technology tools and mitigation techniques necessary to achieve carbon neutrality by the year 2050. The availability of land, the population density, and the demographic patterns of a region are the primary contributors to its distinctive traits. Even though Japan has

limited alternatives for carbon dioxide removal (CDR) and resources when it comes to onshore wind and solar power, and even though Japan's population is falling, this will result in a major reduction in the country's future demand for energy. In contrast, countries like Australia and the United States have an abundance of renewable resources, but they have difficulties in reducing emissions from industry and transportation due to rising populations and high energy use on a per-person basis. The ongoing transition to a power system that is based on renewable resources could be put in jeopardy in the EU due to a lack of social support or EU-wide coordination. CDR solutions are required in every region because it will not be possible to eliminate all residual emissions by the year 2050. CDR has the potential to decrease the required transition pace, depth, and costs, particularly for Australia and the United States. At the same time, this presents the possibility of a carbon lock-in, which occurs when efforts to reduce carbon emissions are reduced in anticipation of carbon dioxide removal technologies that fail to deliver. According to the findings of our study, collaboration among industrialized economies that is centered on shared priorities and the utilization of complementary capabilities may be beneficial. This may involve the trading of fuels and materials that are powered by electricity, as well as the sharing of regional knowledge and expertise on the scaling up of technologies and the implementation of policies.

This research [8], investigates the many approaches that might be taken to handle carbon in organizational contexts. It examines and evaluates the use of the carbon management hierarchy (CMH) by a selection of corporate bodies in the United Kingdom through the use of a sequential mixed methods approach. This approach consists of a literature review, discussions with sustainability thought leaders, an online survey, and interviews with company sustainability leaders. The empirical evidence base that was produced makes it possible to have a triangulated view of the way things are now working and the ways they could be improved. The carbon management models that are in use today are flawed because they are ambiguous with regard to the operational reductions that are required prior to offsetting, and they make no mention of Science Based Targets or the role that corporations could play in wider sustainability initiatives. These are all problems that need to be fixed. An updated version of the CMH that considers broader sustainability initiatives, a number of different offsets, the incorporation of accounting systems, and an

annual review mechanism are all under consideration as potential ways to speed up the journey toward carbon neutrality. If such a model were to become widespread, it would result in more rapid reductions of carbon emissions and attempts to mitigate their effects, better certainty in the authenticity of carbon offsets, broader implications on sustainability, and a faster path toward carbon neutrality.

It is responsible for 6.7% of the nation's total greenhouse gas emissions in Germany. The shift to hospitals with lower carbon footprints involves in-depth understanding of the amount of greenhouse gas emissions as well as the sources of those emissions. The purpose of this research [9], was to document the current state of the reporting of greenhouse gas emissions by German hospitals and to investigate the characteristics of those reports. As a result, they carried out a grey literature review using inclusion and exclusion criteria that had already been established. The search approach consisted of manually searching particular databases, specified websites, and web search engines using a predetermined set of search phrases. They discovered that 12% of Germany's total hospitals had reported their greenhouse gas emissions, which equaled 232 hospitals. Despite this, there were only 62 hospitals (three percent) that satisfied the inclusion criteria for the subsequent analysis. These reports do not cover all greenhouse gas emissions that are related to energy, leave out GHG emissions that occur upstream and downstream of hospitals, and primarily include CO_2 while excluding other types of GHG. As a direct consequence of this, there are significant gaps in the reports of GHG emissions from German hospitals. In order for Germany to fulfill its obligations under the Paris Agreement, the nation's healthcare facilities must be required to adhere to a uniform approach for the reporting and reduction of greenhouse gas emissions.

In the course of this research [10], an integrated carbon accounting and mitigation (INCAM) framework has been developed. This framework has the potential to serve two purposes: the first is the tracking of emissions in a site-specific area, and the second is the identification of potential strategies for reducing emissions in an all-encompassing way. INCAM was developed through a series of methodical steps, the most important of which are as follows: (1) Define Carbon Accounting Centre (CAC); (2) Establish carbon

emission indicators (CEI) for each CAC and CPI; (3) Identify the hot spot for each CAC; and (4) Propose emission reduction strategies and rank emission mitigation measures according to cost effectiveness. INCAM provides useful information that makes carbon profile apparent to various levels of an organization. This enables businesses to plan, make decisions, and take effective action to cut emissions in the direction of greening their industries.

This required carbon reporting is used throughout this article [11], as a jumping off point to investigate broader issues regarding corporate social responsibility as well as the purpose, practice, and implications of such non-financial reporting. Empirically, it combines documentary analysis of the carbon reporting practices of 176 large firms listed in the FTSE100 and/or subject to the UK government's adaptation reporting power with 60 interviews with stakeholders involved in carbon reporting. This was done in order to arrive at its findings. The disclosure of a company's emissions might be a response to financial incentives, social pressure, or the compulsion of regulatory authorities. In turn, rationales determine whether carbon reporting influences internal corporate processes and performance, as well as how this influence occurs. There is limited evidence that carbon reporting is driving considerable reductions in emissions, despite the fact that the significance of reporting to the bottom line differs from industry to industry and depends on two variables: energy intensity and the status of economic regulators. The findings imply that there are good reasons to be cautious about promises that corporations may be "nudged" to improve their environmental performance and social responsibility through disclosure requirements.

According to previous study, this paper explore a unique study regarding human emissions of carbon (CO2) optimization, Specially for organization. Implementing a real-time platform that is able to provide insights on the organization's most recent emission statistics is one creative approach that has been proposed as a response to the issue that was described above. Data on the activities related to emissions will be collected directly from the staff members.

2. RESEARCH PROBLEM

Globally, governments have implemented legislation mandating a significant reduction in greenhouse gas (GHG) emissions in order to implement the Paris Agreement and mitigate the effects of climate change [6]. Countries around the world apply a number of regulations to limit GHG emissions. As a result, corporations must monitor their GHG emissions and report them to their respective governments, and organizations must publicly declare their GHG emissions [7]. Some governments employ carbon credits (the total amount of greenhouse gas emissions that enterprises are permitted to emit) as a tactic to attain carbon neutrality.

Even while minimizing carbon emissions is an important responsibility for every organization, there are times when it is not possible to seek alternative sustainable choices. The majority of these emission sources are directly tied to business processes, and there is no alternative that will not have an influence on the effectiveness of the firm. Nonetheless, there are numerous emission sources (e.g., electricity, transportation, generator, equipment, etc.) within a company that can be lowered in order to attain the required emission objective [9]. There should be a technique to discover the optimal solution for these limits on emission sources [10].

There is no way to compare their existing emissions to their goal (emission gap). If the business analyst is unaware of their present carbon emissions, it will be exceedingly difficult to avoid exceeding the emission limit. Therefore, there is a need for real-time monitoring and optimization of an organization's GHG emissions on each emission source based on consumption constraints [8], and if the emission exceeds the limit, the business analyst should be notified.

3. RESEARCH OBJECTIVES

3.1. Main Objectives

Create a cross-platform mobile application platform for carbon emission management and optimization. Implementing a real-time platform that provides insights into the organization's most recent emission statistics would be an innovative solution provided for the case described above. Employees' emission activity data will be collected directly. With the use of an information retrieval procedure, relevant emission factors will be identified for each emission activity input. Any misinformation will be cleared with the employee before proceeding. To prevent erroneous computations, input units will be validated using text categorization and natural language processing, and values will be converted prior to calculating emissions. Calculated emission values will be kept for analytical purposes, and business analysts will be able to access real-time data using any business intelligence platform. For the restrictions supplied on the emission sources and emission cap, optimization algorithms will develop an optimal solution, and alarms will be sent if the optimal solution is violated.

3.2 Sub Objectives

Using Optimization Algorithms, identify the ideal solution for the given emission source limitations and send an alert for any violations of the optimal solution.

The business analyst will offer information on usage restrictions for many emission sources. Using optimization models, a minimally optimal solution will be provided for these restrictions and emission cap. This can be modified by business analysts in accordance with their changing requirements. Once an optimal solution has been established, the maximum emission value provided by the solution for various

emission sources will be set as the maximum thresholds, and alerts will be delivered via SMS API gateways if these values are exceeded.

3.4 Requirements

User Requirements

- Proper working mobile
- Basic knowledge to manage the App
- Able to work with mobile phone
- Good connection without any lag issues
- An android or IOS smartphone with microphone
- Internet connectivity

Functional Requirements

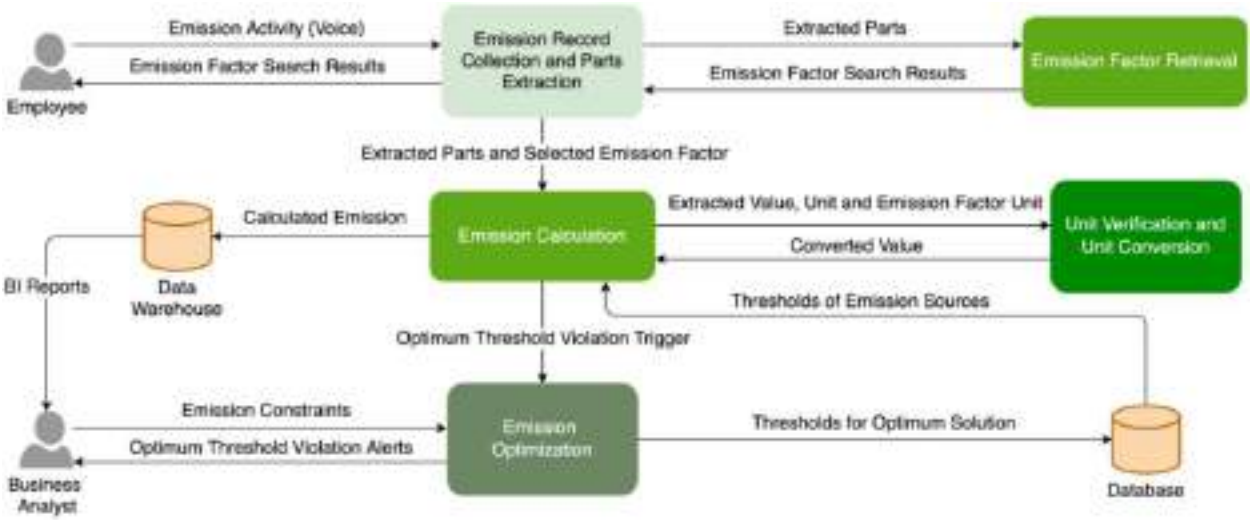
- Find optimal solution using given usage constraints.
- Create thresholds on different emission sources according to the chosen optimal solution.
- Implement alert framework to notify to the BA when emission exceed the limit
- Build a cross platform mobile application

Non-Functional Requirements

- Speed or performance – response time
- Size – Use less resources
- Scalability – Scaled to new factor standards
- Ease of use – No need of training or education
- Reliability – Available as much as possible

4. METHODOLOGY

4.1 Methodology



As can be seen in Figure 1, the system that is being suggested (Carbonis) is comprised mostly of the following four components:

1. The gathering of emission records and the extraction of portions

As a form of natural language input, employees' emission records will be collected from them. The relevant components of the emission activity, such as emission technology, consumption value, consumption unit, date, and so on, will be retrieved from these input data. These converted components will be given to the emission factor retrieval component, and the user will be shown the results when they have been retrieved so that they can make a selection from among them. After the worker has selected an emission factor appropriate for the task, the extracted parts and the selected emission factor will be supplied to the portion of the calculation that deals with emissions.

2. The retrieval of the emission factor and the computation of the emissions (focusing component of this proposal)

The component responsible for retrieving emission factors will search for and rank emission factors that are a match for the extracted parts and any other organizational aspects, and then it will present the employee with these results for selection. Following the confirmation of the emission factor, the extracted parts and selected emission factor will be obtained for use in the computation of emissions. The value of consumption, the unit of consumption, and the unit of the emission factor will be transferred to the component responsible for unit verification and unit conversion to check that the units are consistent with one another. After the unit conversion has been finished, the emission will be computed and then saved in a data warehouse (in a dimensional model) for business analysts to access via self-service business intelligence (BI). The optimal solution threshold violation will be verified whenever there is a new emission addition, and alert triggers will be provided to the emission optimization component whenever there is a violation of any kind.

3. The checking of units and the converting of units

It shall be ensured that the consumption unit and the emission factor unit that is provided by the module that calculates emissions are comparable to one another. In the event that these units do not correspond, the values of the consumption will be converted such that they correspond with the unit used for the emission factor. The value of this consumption once it has been transformed will be provided for the computation of emissions.

4. Module for the minimization of emissions

An optimized solution will be obtained for the firm's available emission credits and limitations on its various emission sources. The thresholds on the firm's various emission sources that apply to this optimal solution will be saved. Warning notices will be distributed to responsible BAs in the event that a threshold is breached and triggered.

.

4.2. System Architecture

The implementation of a real-time platform that is capable of providing insights into the organization's most recent emission information is one creative solution that has been presented for the circumstance that has been stated. The data on the employees' emission activity will be obtained directly from the employees themselves through the use of a digital assistant. For each type of emission activity input, a specific information retrieval technique will be carried out in order to calculate the relevant emission factors. Any misunderstanding will be discussed and resolved with the employee before moving forward. Before any calculations regarding emissions are made, the input units will be inspected using text categorization and natural language processing, and the results will be translated. These steps will help ensure that no errors occur. The computed emission levels will be kept so they may be analyzed later; business analysts can get this real-time data using whatever business intelligence platform they choose. An optimal solution would be constructed for the constraints provided on the emission sources and the emission cap by applying optimization techniques, and alarms would be sent if there was any breach of the optimal solution. The restrictions would be on the amount of emissions that could be produced.

The emission optimization interface of the mobile application will be utilized to collect data on the usage limits of each emission source. After then, optimization algorithms will be used to discover the best possible solution while taking into account the stated limitations. The minimum optimal solution is going to be used to determine the maximum threshold values for each source of emissions. The maximum threshold values will be checked with the business analyst to ensure they meet the requirements of the business. After a confirmation from the business analyst, the threshold values will be saved on the application database. Following that, the threshold values for each source of emission will be compared with each emission from a variety of sources. In the event that emissions exceeded the limit, an alert will be issued to BA over the SMS API gateway.

1. Putting in place a specialized emission optimization module that considers the various limits placed on different sources.

- This component will return an optimal solution to minimize emissions by using the limitations on emission sources as an input and determining what that optimal solution is.
- Request that the business analyst provide you with consumption limitations on the various sources of emissions produced by the enterprise (BA).
- Construct an optimization model with the help of an appropriate optimization technique in order to locate the optimal solution that satisfies both the limits placed on the emission sources and the total emission limit imposed on the organization.
- Let BA configure and choose an appropriate ideal solution.
- Determine the thresholds for each of the various emission sources based on the optimal solution that was selected.

2. Establishing a structure for alerts in order to notify users of any thresholds that have been exceeded after the ideal solution has been implemented.

- While adding a new emission record, it is important to check to see if any of the thresholds that the optimal solution provides are being exceeded.
- Notify the BAs immediately of any threshold violations that have occurred.

3. Implement a mobile application using React Native with expo cli. The implementation of a mobile application that is cross-platform will be handled by React Native, and expo cli will be used to gain access to the hardware components such the microphone and the speaker.

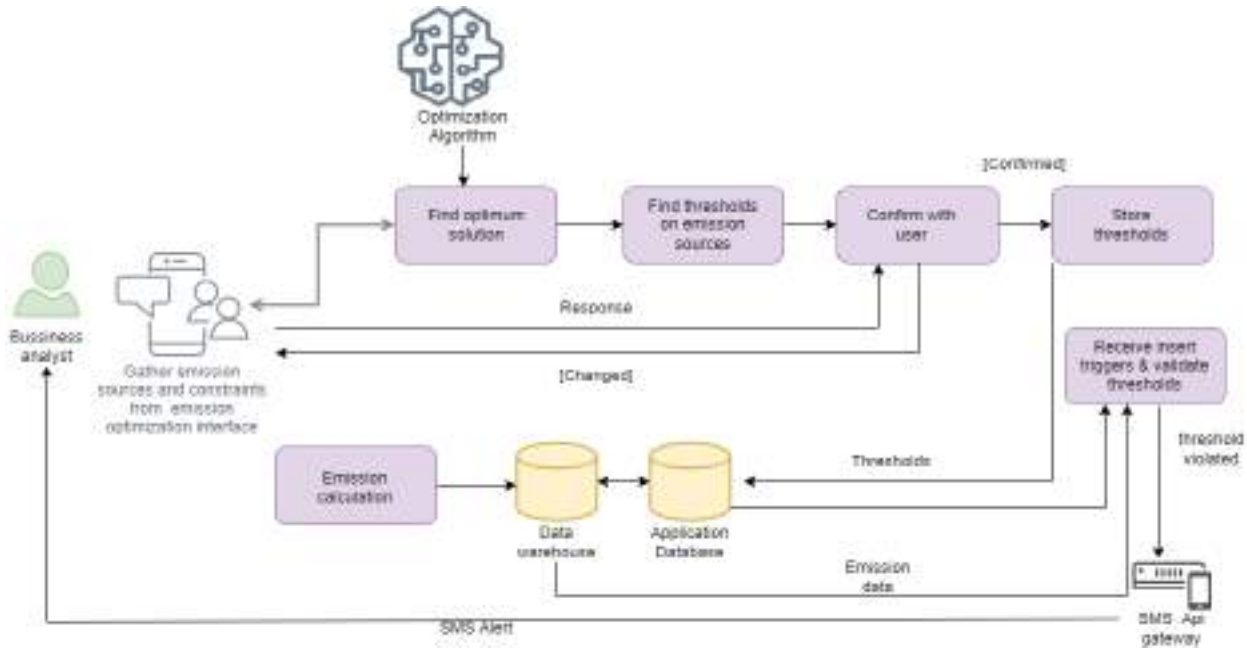


Figure 1: Component Flow Diagram

To begin, a linear programming approach was taken in the development of the system to neutralize carbon. The application that was produced via the use of optimization algorithms was then put through its paces by being tested with carbon emission data from a particular company in order to determine whether or not it was functioning appropriately or whether it had any limits. The portions of the technique that were used to track and assess the user interface experience of the organization as well as the system backend processing were broken up into many sub-sectors so that research could be conducted more easily.

4.3 Objective Function

The term "objective function" is used in the context of linear programming problems to refer to the real-valued function whose value must be either maximized or minimized according to the constraints that are defined on the specified linear programming problem over a set of possible solutions. In other words, the value of the objective function must be either maximized or minimized. It is, in essence, a mathematical expression that expresses the goal of the task and has the potential to be made as large or as small as feasible. The objective function is a linear function with the form z = ax + by, and it's used to measure progress toward the goal. Your purpose for solving the linear programming issue will tell you whether you should try to maximize or minimize the value of the objective function. In most cases, it is used to reflect either costs or profits.

The relationship that exists between the input and output of a system, which is represented by a function, is what is meant to be defined by the optimization function.

An objective function is essentially the system objective that is portrayed in the form of a function of decision variables while discussing optimization.

When performing multi-objective optimization, it is necessary to simultaneously optimize a great deal of these objective functions.

Both the problem's objective function and the constraints that are imposed on it must be deterministic, and they must be able to be stated in linear form. Because of these

constraints, the total number of issues that can be immediately addressed is restricted in some way.

It's possible that linear programming is the most often applied form of mathematical optimization, and there are a number of different computer tools that can solve linear programming problems if you run into any difficulties.

Problems such as the blending of oil and chemicals in refineries, the selection of vendors or suppliers for large manufacturing companies with multiple plants, the determination of shipping routes and schedules, and the management and maintenance of truck fleets are all examples of situations in which linear programming techniques are used quite frequently.

Objective functions played a significant role in the articulation and resolution of the operational challenges associated with linear programming. All variables were employed as the objective function in the study because the primary purpose of the research was to determine how to minimize carbon emissions from a given set of carbon emission sources.

$$P = E1+E2+E3+E4 \ldots\ldots\ldots + En$$

E_n – *emission from different sources*

P – objective function of carbon emission operational research

The optimization algorithm needed to reduce objective function as much as possible in order to meet the emission target. The computation of emissions was performed by considering the consumption of the emission activity and a particular emission factor. The amount of emissions can be calculated by taking the consumption and multiplying it by a specific emission factor. When measuring carbon emissions, kilograms of carbon dioxide are typically used as the benchmark.

$$E = \text{specific emission factor} * \text{consumption}$$

So,

$$P = F1 * C1 + F2 * C2 + F3 * C3 + \ldots + Fn * C_n$$

$$P = \sum Fi * Ci$$

Following the completion of mathematical modeling, an automated and real-time technique of designing the optimization system was carried out. A platform that allows users to personalize the limitations and total optimization cap to meet their own needs. The user will provide an optimization cap as input, as well as a lower and upper bound for the consumption of each emission source. These constraints are known as constraints. The user will determine the threshold for each source of emissions by making use of the aforementioned limitations and objective functions. The best possible option would be helpful for keeping the carbon limit from being exceeded while also sustaining it.

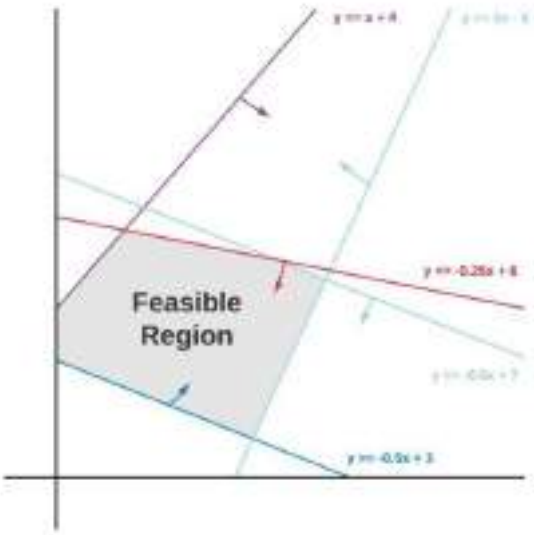


Figure 3: Objective Function

4.4. Optimization algorithm

Python's optimization-algorithms package provides a collection of helpful algorithms that may be applied to a wide variety of challenging situations, including partitioning, floor design, and scheduling. This library will include several different implementations for a wide variety of optimization methods. This library has a structure that is grouped according to problems.

4.4.1. Algorithm Design

A mathematical model was initially transformed into an algorithm to determine the most effective optimal solution for each emission source. In this study, we used the Pyomo framework as per analysis, which was useful for algorithm implementation using python, and to solve this linear programming optimization. In Pyomo, Declaration modeling elements like variables were rather simple. Expressions that represent the objective function and constraints were specified. It is crucial to specify the sense of an objective function when stating one, such as whether to maximize or minimize provided expression.

4.4.2. Linear programming optimization

In the field of math, straight writing computer programs is a strategy for enhancing processes that are dependent upon specific cut-off points. The essential objective of direct writing computer programs is to augment or limit the mathematical worth that is being worked with. Comprised of straight capabilities are obliged by the given circumstances as direct conditions or imbalances, individually. It is generally recognized that straight writing computer programs is a significant technique for deciding how to make the most efficient use of available resources.

The challenge of maximizing or minimising the value of a linear function while adhering to linear restrictions is referred to as linear programming (LP), which is also sometimes referred to as linear optimization. Equalities and disparities could both serve as the limitations. The calculation of profit and loss is required for the problems of optimization. The class of optimization issues known as linear programming problems is an important one because they facilitate the process of locating the feasible region and optimizing the solution in order to obtain the highest or lowest possible value for the function.

To put it another way, straight writing computer programs is a technique for improvement that is utilized to expand or limit the goal capability of a given numerical model with a bunch of certain prerequisites that are addressed in a direct relationship. This should be possible by boosting the worth of the goal capability or by limiting its worth. Finding the arrangement that is best for the straight programming issue is the essential target of the activity.

The process of considering various inequalities that are pertinent to a scenario and calculating the best value that must be produced under those conditions is known as linear programming. When working with linear programming, some of the assumptions that are made are as follows:

It is necessary to use quantitative language when expressing the amount of restrictions.

It is desirable for there to be a linear connection between the restrictions and the objective function.

It is necessary to perfect the linear function, often known as the objective function.

The linear programming problem can be broken down into five distinct properties, which are as follows:

Regarding the available resource, the constraints, or limitations, should be described in the form of a mathematical equation.

Function Objective - The objective function of a problem needs to be stated in a quantitative manner in order to be solved.

In order for the function to be linear, the connection between any two or more of its variables must be linear. It denotes that there is just one possible value for the variable in question.

The number of possible inputs and outputs should both be finite and infinite respectively. In the event that the function contains an infinite number of elements, it is not possible to implement the optimal solution.

Non-negativity requires that the value of the variable be either positive or zero. It should not have a value that is less than zero.

Choice Variables: The value of the output will be determined by the decision variable. It provides the most comprehensive answer to the situation. In the initial step of solving any problem, you must first determine the decision variables.

4.4.3. Problems Involving Linear Programming

The Linear Programming Problems, sometimes known as LPP for short, are problems that involve determining the best possible value for a linear function that is provided. Either the highest possible value or the lowest possible value could be considered the best value. In this context, the linear function that has been supplied is regarded as an objective function. The objective function may include a number of variables that are governed by the conditions, and it must be able to meet a set of linear inequalities that are known as linear constraints. The linear programming issues can be used to achieve the optimal solution for the following scenarios, such as manufacturing problems, diet problems, transportation problems, allocation problems, and so on. The linear programming problems can also be used to solve other types of problems.

4.4.4. Techniques for Resolving Issues Arising from Linear Programming

The problem of linear programming can be handled in a number of various ways, including the graphical technique, the simplex method, or by utilizing a number of different tools, such as R, open solver, etc. In this section, we will have an in-depth conversation on the two most significant approaches, which are respectively known as the simplex method and the graphical method.

4.4.5. Method Based on Graphics

In order to achieve optimal performance in the two-variable linear programming, the graphical method is applied. If there are two choice variables involved in the issue, the graphical method is the most effective approach to finding the best possible answer. In this approach, the list of inequality conditions is constrained using various criteria. The inequalities are then shown in the XY plane after this step. When all of the inequalities have been shown in the XY graph, the region where they cross will be used to assist determine the region that is viable. The optimal answer will be provided by the feasible region, and an explanation of all the values that our model can take will also be provided by this region. Let's have a look at an example of linear programming in action so that we can get a better grasp on the idea behind it.

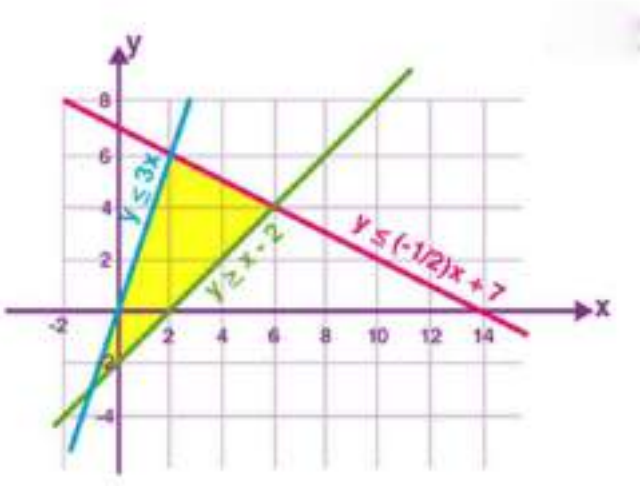


Figure 4: Method Based on Graphics

```
model.obj = pyo.Objective(expr=E1+Ef2+E3+E4+E5 , sense=minimize)
```

Figure 5: Objective Function on Pyomo

After the declaration of variable and constraints, the model was passed through the solver to solving the linear operational problem. In this research, we chose GLPK as solver after comparing with some other solvers.

4.4.6. Linear Programming Model in Pyomo

Pyomo and its additional files, in addition to the glpk (MILP) and ipopt (nonlinear) solvers, will be installed with the following commands.

```
conda install -c conda-forge pyomo
conda install -c conda-forge pyomo.extras
conda install -c conda-forge glpk
conda install -c conda-forge ipopt
```

Creating at least two Pyomo objects from one of the following classes is required in order to run a typical application written in Pyomo:

A Python object called ConcreteModel() that represents the optimization problem that needs to be solved.

Python object that represents the mathematical programming software that will be used for the calculation of a solution. SolverFactory() is a function.

Pyomo is compatible with a variety of different solvers, including those that are open-source and those that are for sale. This straightforward framework makes it possible to test and identify solvers that are best suited to a certain application.

A model, on the other hand, is made up of supplementary objects that are utilized to specify an issue. For the creation of meaningful models, only a core group of classes is required. These categories are as follows:

- Objects returned by the Var () function that represent values of variables found while working through a particular issue.
- An object that represents the objective function of the problem, which can be either minimized or maximized depending on the situation.
- Constraint() Objects representing problem limitations.
-

4.4.7. GLPK

The GNU Linear Programming Kit (GLPK) solver is an open-source tool that was developed to tackle linear programming, mixed-integer, and other problems that are linked to these types of programming. With the use of an application programming interface (API), it may be quickly accessible and utilized through Python PuLP. The problem of linear programming that has been presented is solved by PuLP by selecting an API solver from a list of possible optimizers. We can view the list of solver APIs that PuLP is able to access by using the listSolvers() method that it provides:

```
1  print(listSolvers())
2  print(listSolvers(onlyAvailable = True))
```

Framework

framework	Linear problems	Non-linear problems	How easy to start with	How easy to configure a new solver and about documentation
Pyomo	✓	✓	High	High
Ortools	✓		Very high	Low
PuLP	✓		High	High
SCIP	✓	✓	Very high	Low
SciPy	✓	✓	Low	Medium

Table 4.1: Framework Comparison

Solvers

Solver	Linear problems	Non-linear problems	Free/ commercial
Gurobi	✓		**Commercial**
Cplex	✓		**Commercial**
CBC	✓		**Free**
GLPK	✓		**Free**
IPOPT		✓	**Free**
SCIP	✓	✓	**Free**
Baron		✓	**Commercial**

Table 4.2: Solvers Comparison

4.5 Alert Framework

Using linear programming algorithms, users can determine the best emission threshold for each source of emission. However, it is unclear how they plan to reduce emissions and achieve carbon neutrality. In this study, we created an alert framework to solve this problem. The user will be warned if any thresholds are violated. It is an application that compares the present emission with the optimum threshold in real-time.

A solution in the form of an algorithm is offered for situations involving constrained linear programming. The Quick Convergent Inflow Procedure (QCIA), which is utilized in the process of solving linear programming problems, serves as the foundation for this method; nevertheless, it takes into account the influence that segmentation of the design or viable regions has on the algorithm. A halting rule that is proposed that is based on the ideas behind variance exchange algorithms is described here. The objective function may be shown to converge to a global optimizer by the use of numerical demonstrations, which proves that the technique works.

The motivation behind direct writing computer programs is to expand or limit a straight capability, f(x1, x2,..., xn), of n factors characterized on a plan or possible district whose limit is portrayed by straight disparities and conditions. At the end of the day, the objective of straight writing computer programs is to expand or limit a direct capability. The straight capability can be communicated in numerical structure as follows:

$$f(x_1, x_2, \ldots, x_n) = \sum_{j=1}^{n} c_j x_j$$

where cj is the coefficient of the variable xj. Using the simplex approach or one of its many variations, it is possible to find solutions to the difficulties posed by linear programming (LP). In addition, statistical techniques have been employed in the process of finding answers to challenges relating to LP. Quick Convergent Inflow Algorithm (QCIA) is a method that was developed by Odiakosa and Iwundu (2013) for the purpose of addressing linear programming issues. In its capacity as a line search tool, the algorithm makes advantage of the experimental design concepts provided by Onukogu and Chigbu (2002). The design measure has a bound for

the number of support points, denoted by N, which is as follows: pN12p (p+1)+1. Although the algorithm is efficient in solving linear programming problems and performs favorably when compared to other methods, such as the simplex method, the linear exchange algorithm of Umoren (1999), and the quadratic exchange algorithm, it is possible that the QCIA may converge locally in some problems if the stopping rule is applied. This can be avoided by applying the rule consistently across all problems. In addition, there is a possibility that the method will not always arrive at the best solution for the linear objective function when the design size is limited by pN12p(p+1)+1. When dealing with issues like these, the inflow method is unable to converge on the requisite optimal solution.

4.6 User Interface Design

To create a mobile application platform for organizations to manage and optimize their carbon emissions, an innovative solution was proposed for the above scenario to implement a real-time platform that can provide insights into the most up-to-date emission statistics of the organization. Emission activity data will be directly gathered from the employees. The research approach was begun by testing private business organizations with the chance of High carbon emissions. The User Interface was designed in a way in which the tasks were split and easy to understand. Initially, the system blueprint was given to the Business analyst (User) for testing. First, BA (Business analyst) was provided with which optimization they want to perform. Once the BA selected the create new optimization, they can create the carbon optimization. After the relevant optimization was selected, BA was instructed to enter the details like Optimization Cap, Date and Organization ID. Optimization Cap refers to the amount which the organization wants to allocate for the specific type of optimization sector. BA must be aware of the organization's total emission cap and input the necessary amount. This was given strictly organizational based, and the BA had to input the necessary amount. The date was given normally, and the organization ID was the unique ID for organization. Once the details were given the BA was directed to the Employees transport window. In the Employees transport window, some of the important details for the carbon optimization like Emission source, constraints, constraints name, and type were given. Emission source means the name of the vehicle which the employee uses. These source pieces of information are unique to every brand they use, and the numbers were given for every car. Constraints mean the carbon optimization amount value that BA wants to give for that

specific vehicle. It varies from source to source. This data was fundamental in optimization calculation. Constrain name means whether that optimization constraint is upper bound or lower bound. This can be useful if BA wants to give the constraint data in a range. Lastly, the type means the emission source type that BA wants to select. The types and related materials were given to BA so that they can refer to the handbook easy access data about the type of emission source to fill the column. As the last step, the Emission limit of a specific emission source was displayed on the app itself. This was processed through our smart algorithm and optimized for the relevant threshold which each emission source can bear. This real-time emission limit window was designed to be updated automatically so now BA can track how much each emission source was assigned. Once the emission source reached its threshold system will send the notification alert to BA to take further actions.

4.7. Technologies

4.7.1 Python language

Python is a flexible programming language that may be used for a wide range of tasks. Web programming, artificial intelligence (AI), machine learning (ML), operating systems, mobile app development, and video game development are all areas where Python is used. Python is a well-structured programming language that is easy to learn. This, together with its versatility and simple syntax, makes it a great programming language for a variety of applications. Python is a popular back-end programming language due to its easy syntax and broad server-side usage. As a result, I used Python to create my front-end and back-end applications. Python is widely utilized in the process of producing websites and applications, as well as for automating tasks, analysing data, and visualizing data. Python is used for a wide variety of day-to-day operations, including the organization of money, by many non-programmers such as accountants and scientists. This is due to the fact that Python is reasonably straightforward to learn. The PuLP library is a robust resource that enables Python programmers to resolve issues of this nature by writing only a few lines of code. My research has led me to conclude that PuLP is the library that provides the least complicated solutions to situations involving linear optimization.

4.7.2 PyCharm

We utilized the PyCharm community edition platform to write the backend code. PyCharm is one of the most widely used Python IDEs. PyCharm is licensed software for Python programmers. PyCharm's Community Edition can always help developers save money on software development. Some of the advanced capabilities available in professional editions are still unavailable in the community edition.

4.7.3 Jupiter

Jupyter Notebook is a piece of open-source software for collaborative programming that allows users to write, edit, and execute code in a wide variety of today's most popular programming languages. Within the area of programming, notebooks serve as a one-stop-shop that enables you to work on all phases of the data analysis process on one interactive page.

Before beginning to use the data to make suggestions or predictions, you must first complete the time-consuming process of data cleaning. This process requires that your data be organized in such a way that the parts of the dataset that you do not want can be easily identified and removed from the dataset. Because it is compatible with a wide variety of tools, Jupyter Notebook can also be used to facilitate the streamlining of the process of organizing and cleansing data.

The process of cleaning and organizing your data can be made much more efficient by installing additional tools within Jupyter Notebook. Some examples of these additional tools include Jupyter Innotator. Users of Jupyter Innotator have the ability to define boundaries and boxes around images, as well as use drop-down menus to classify and categorize various components of the dataset. After you have cleaned, structured, and analyzed your data, you can use Jupyter Notebook to create data visualizations and share them with others. Users of Jupyter Notebook are given the ability to compile all components of a data project in a single location, which makes it much simpler to demonstrate the full process of a project to the audience that you have in mind.
Creating a compressed file or folder that contains all of your information and data is one of the key techniques of data visualization and sharing that can be accomplished through the use of Jupyter Notebook. The URL to this document can then be distributed to the other people working on this project with you or to your pupils. This is one of the most typical ways that data from notebooks is distributed via repositories like GitHub.

4.7.4 Database

Cloud Services

Cloud compute server (AWS EC2)

Amazon Versatile Register Cloud (otherwise called Amazon EC2) is a part of Amazon Web Administrations (AWS) Cloud that offers adaptable figuring capacity. By using Amazon EC2, you can dispense with the need to make an underlying interest in equipment, which empowers you to create and convey applications in an all the more opportune way.

Serverless Backend service (AWS Lambda)

AWS Lambda is a serverless, occasion driven process arrangement that permits you to run code for practically any sort of use or backend administration without first making or oversee servers. Lambda can be set off from more than 200 different AWS administrations and programming as a help (SaaS) applications, and you may be charged for the assets that you truly use.

NoSQL database (AWS DocumentDB)

A NoSQL JSON document database service, Amazon DocumentDB has some compatibility with MongoDB but not all of its features. The DocumentDB server is not derived from the MongoDB database. Instead, it imitates the MongoDB Application Programming Interface (API) and operates on top of Amazon's Aurora backend platform.

MongoDB

MongoDB is a program that operates as a document-oriented database that is compatible with multiple platforms. MongoDB, which is a NoSQL database application, stores data in documents that are similar to JSON and can have optional schemas. MongoDB is built on a scale-out architecture that has become popular among developers of all types for the development of scalable applications with evolving data schemas. MongoDB is licensed

under the Server Side Public License, which is deemed non-free by several distributions. MongoDB was developed by MongoDB Inc. and is licensed under that license.

MongoDB is a document database, which means that it makes it simple for developers to store data in either a structured or unstructured format. Documents are saved in a format that is analogous to JSON by this system. Because this format translates directly to native objects in the majority of modern programming languages, using it is an obvious choice for developers because it eliminates the need for them to worry about normalizing the data. In addition to this, MongoDB is capable of handling massive volumes of data and can scale either vertically or horizontally to accommodate large amounts of data.

4.7.5. React-native

Building native mobile applications with JavaScript is made possible with the help of React Native, which is a framework. Java (for Android) and Swift/Obj-C are the programming languages that are typically used to create mobile applications (for iOS). Because React Native does not require this, developers can create apps that are completely functional on both platforms in a far shorter amount of time and with only one programming language.

Using React Native, you can design a single codebase that is compatible with both iOS and Android. And not only does it "work," but it also compiles to native code for both Java and Swift. To be more specific, React Native acts as a connector between native Java and Swift user interface components and their web-based counterparts.

4.7.6. Expo cli

During the process of app development, the expo package gives you access to a command-line interface (CLI) tool called npx expo that is compact yet extremely powerful. Highlights. Use the command npx expo start to begin the process of creating your app on a server. Using the npx expo prebuild command, you may generate the native iOS and Android directories for your project.

During the process of app development, the expo package gives you access to a command-line interface (CLI) tool called npx expo that is compact yet extremely powerful. Highlights. Use the command npx expo start to begin the process of creating your app on a server. Using the npx expo prebuild command, you may generate the native iOS and Android directories for your project.

Expo Go gives you the ability to execute a React Native project on a real device without the need to install the native iOS or Android software development kits. If you want to test your app on an iOS Simulator or an Android Virtual Device, please refer to the instructions for the "React Native CLI Quickstart" to learn how to install Xcode and set up your Android development environment. These instructions can also help you if you want to run your app on an Android Virtual Device. After you have completed these steps, you will be able to launch your application on an Android Virtual Device by typing "npm run android" into the command line, or on an iOS Simulator by typing "npm run ios" into the command line.

4.7.7. Django

Django is a high-level web framework written in Python that enables the rapid building of websites that are both safe and easy to maintain. Django, which was built by seasoned developers, takes care of a significant portion of the pain associated with web development. As a result, you can concentrate on developing your application without having to reinvent the wheel. It is free and open source, has a community that is flourishing and active, superb documentation, and numerous alternatives for both free and commercial support.

The code for Django is created following design principles and patterns that enable the construction of code that is both easily maintained and reusable. It does this in particular by adhering to the "Don't Repeat Yourself" (DRY) concept, which ensures that there is no needless repetition of code and hence a smaller overall volume of it. Additionally, Django encourages the organization of comparable functionality into reusable "applications" and, on a more fundamental level, it organizes related code into modules (in a manner analogous to the Model View Controller (MVC) design).

A straightforward query application programming interface (API) is provided by the Django model for searching the related database. This may enable complex assertions and can match against a number of fields at the same time using multiple criteria (such as precise, case-insensitive, greater than, etc.). (for example, you can specify a search on U11 teams that have a team name that starts with "Fr" or ends with "al").

4.7.8. Libraires

NumPy

NumPy is a scientific computing package. It is a core library that offers great speed and tools for array objects.

Pandas

The Panda library is an open-source library that facilitates data analysis and is simple to use. It provides a data structure with good performance and ease of use.

Pyomo

Pyomo is a software program that is available under the open source license that may be used to formulate and solve large-scale optimization problems. The software expands the modeling method that is supported by contemporary AML (Algebraic Modeling Language) tools.Python-based utility for creating and analyzing graphs and networks.Modeling and finding solutions to optimization challenges The modeling process is one of the most basic processes in numerous facets of scientific inquiry, technological development, and commercial enterprise. Algebraic modeling

Languages on the same level as Pyomo are high-level languages that can be used to express and solve mathematical optimization issues. Pyomo is a modeling framework that is both versatile and extendable. It encapsulates and extends fundamental notions that

may be found in modern algebraic modeling. languages, all within the framework of a programming language that is commonly used. The purpose of Pyomo is to provide a platform for the specification of optimization models.

It implements the core concepts that are found in contemporary AMLs inside a framework that encourages adaptability, extension, portability, openness, and openness to maintenance. Pyomo is an AML that is an extension of Python and includes objects for the modeling of optimization.

You can specify optimization models with the help of these classes, and then translate those models into a number of forms that can be worked with by different external solvers.

In this section, we will present some inspiring examples to illustrate how Pyomo may be used in defining models for optimal performance.

4.8. Diagrams

4.8.1. Flow Diagram for Feature Extraction

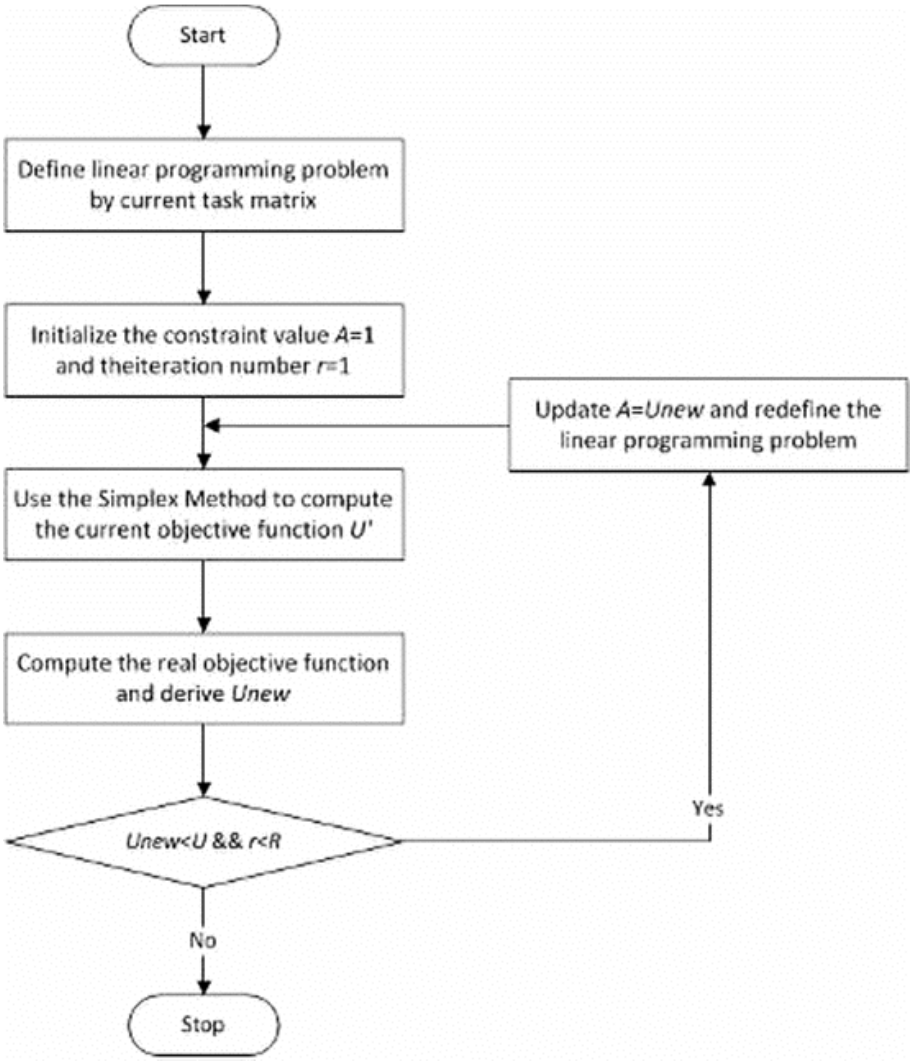


Figure 6: Flow Diagram

4.8.2. Class Diagram

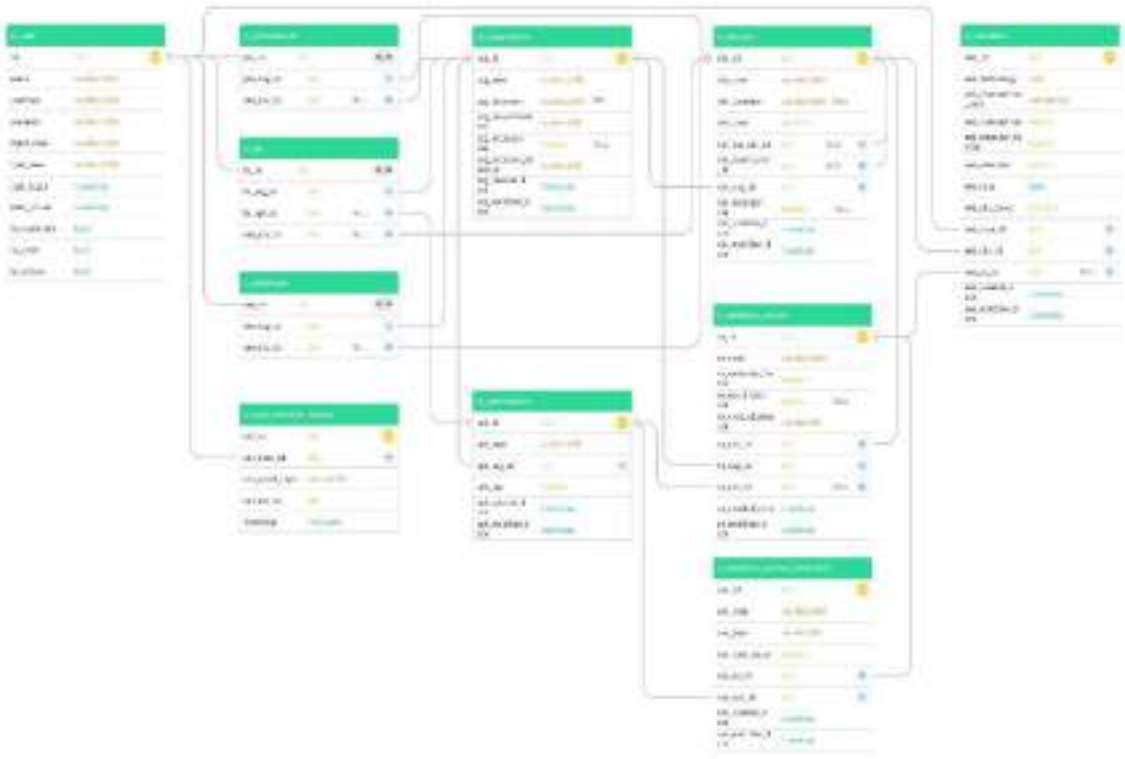


Figure 7: Class diagram

4.8.3. Flow Diagram for Optimization

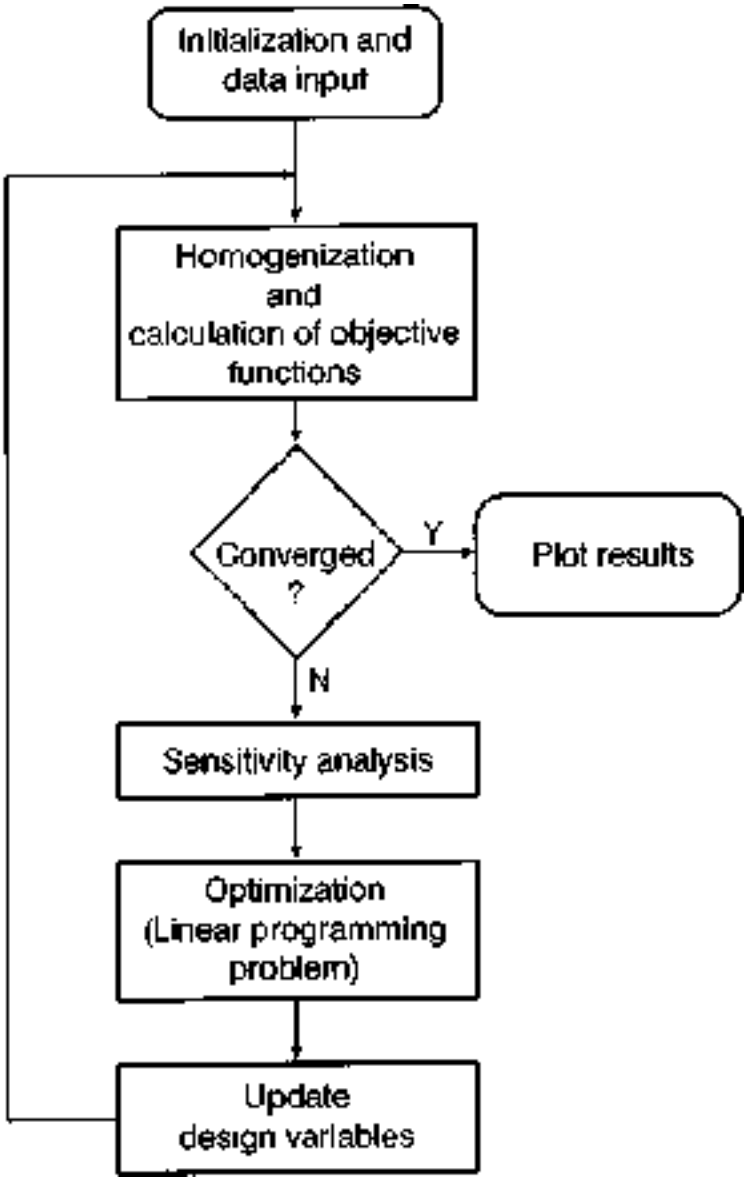


Figure 8: Flow Diagram for optimization

4.8.4. Use case Diagram

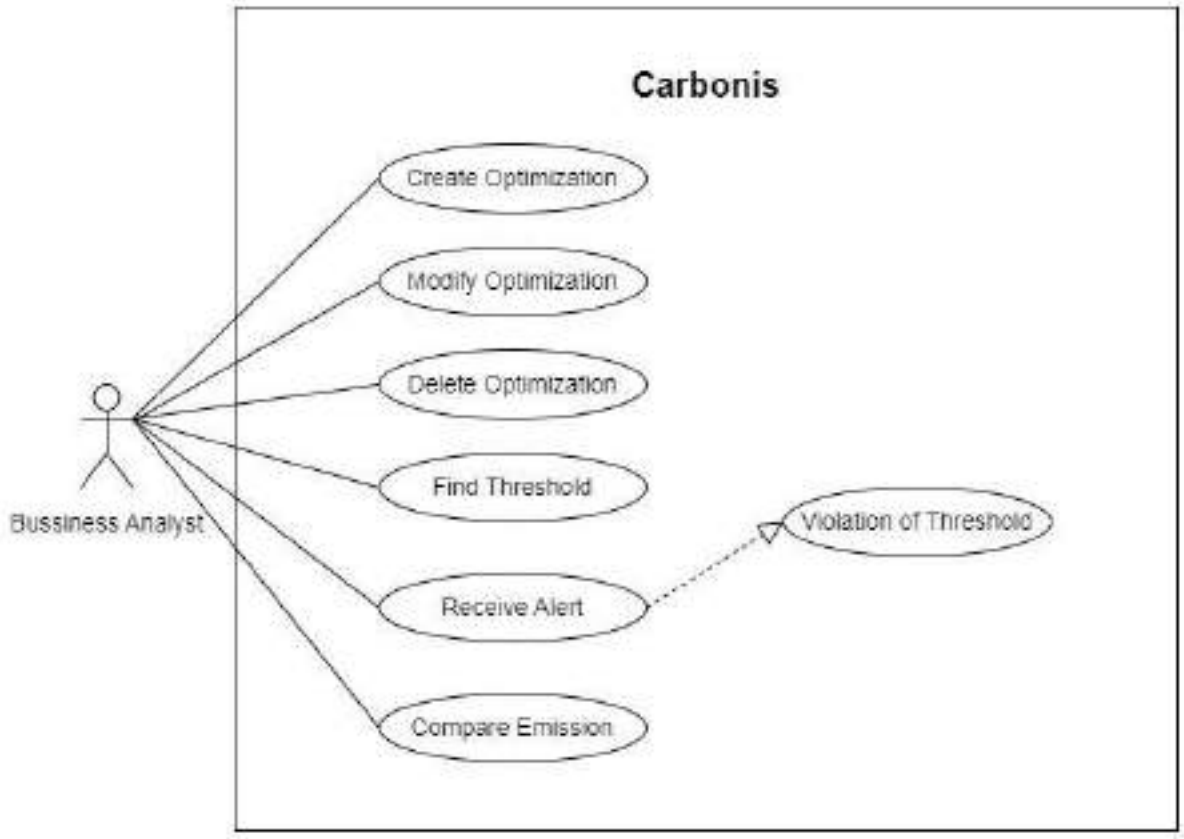


Figure 7:Use case Diagram

4.8.5. Block diagram

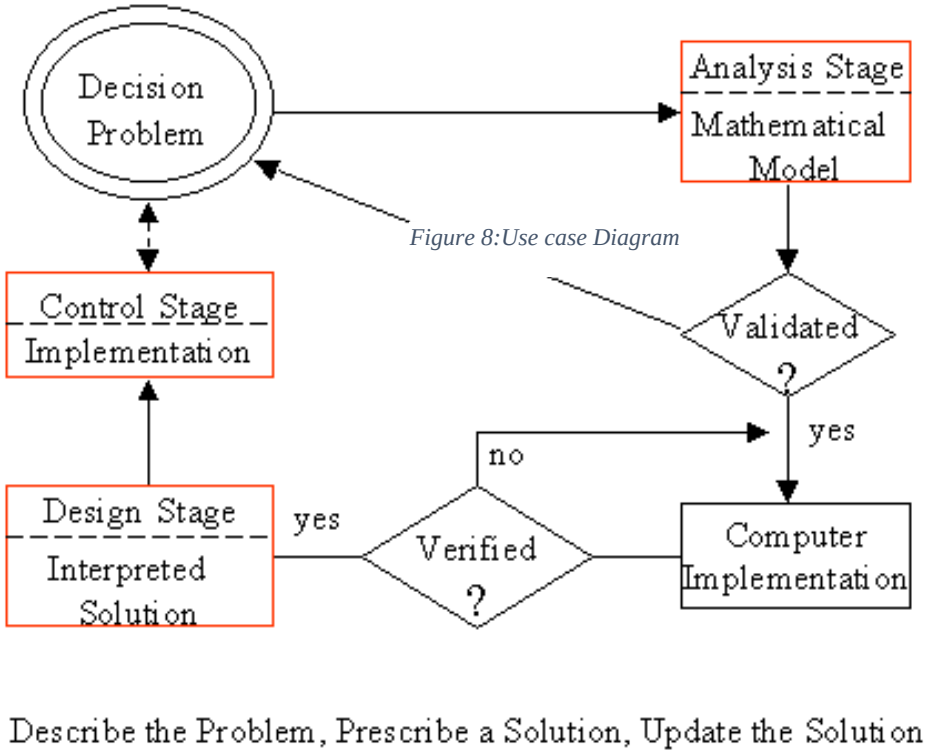


Figure 8:Use case Diagram

Figure 10: Block Diagram

4.8.6. ER-Diagram

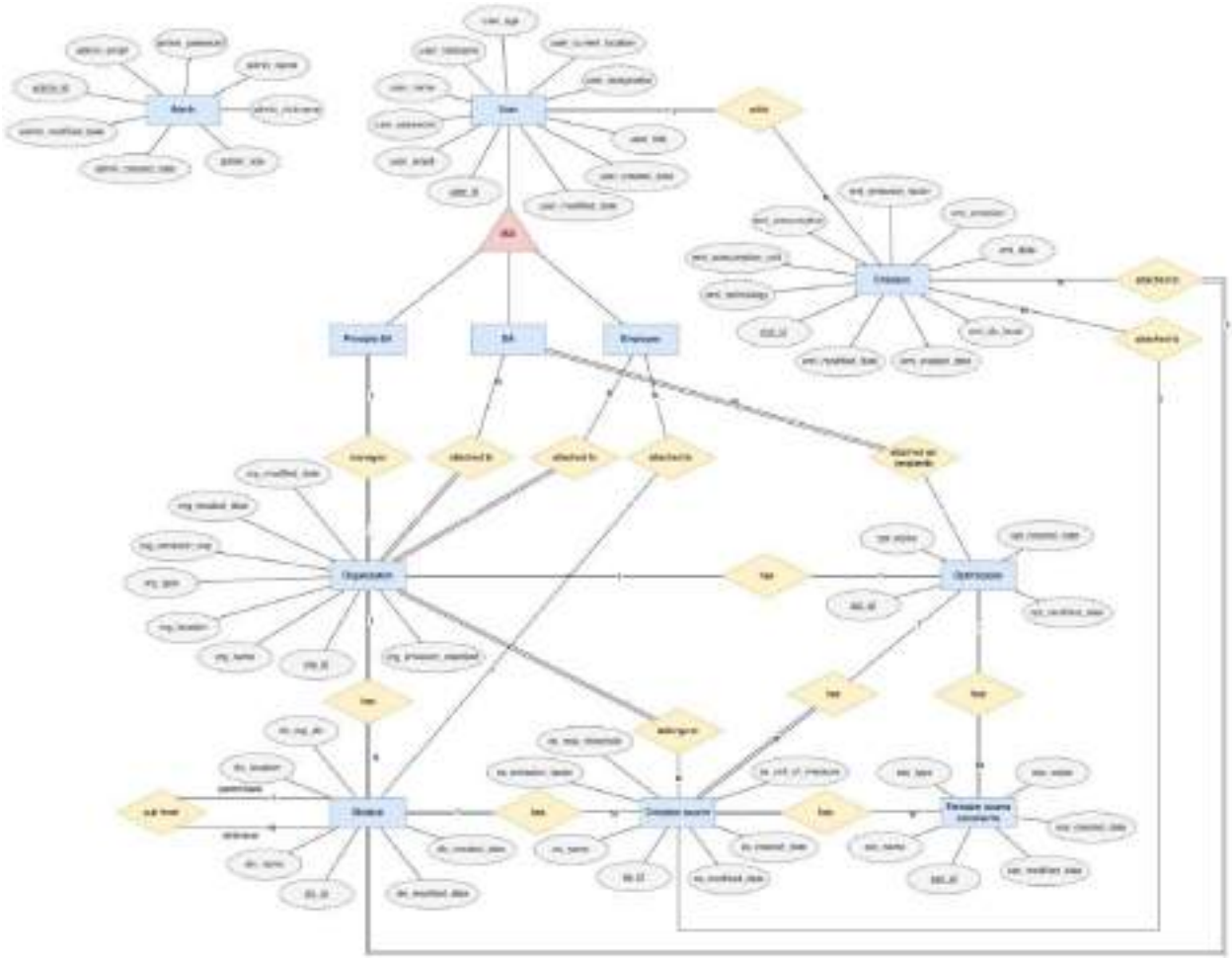


Figure 11: ER-Diagram

4.9. Software Solution

The product development life cycle, often known as the lithe technique, includes the following stages: In addition to this, the Scrum methodology will be used as the framework for the coordinated approach that will be taken. Scrum is a lightweight, coordinated framework for project management that has expanded materiality for monitoring and controlling iterative and continuous tasks, all other things being equal. Because scrum has the ability to analyze and adjust to the modification of requirements, the arrangement that the creators will carry out is contingent on the hypothesis that was completed by the writing research and the review that was carried out, consistent alterations.

Figure 12: Agile Methodology

4.10. Project Management

The administration of each project can be divided into several stages. For our project, the following phases have been identified:

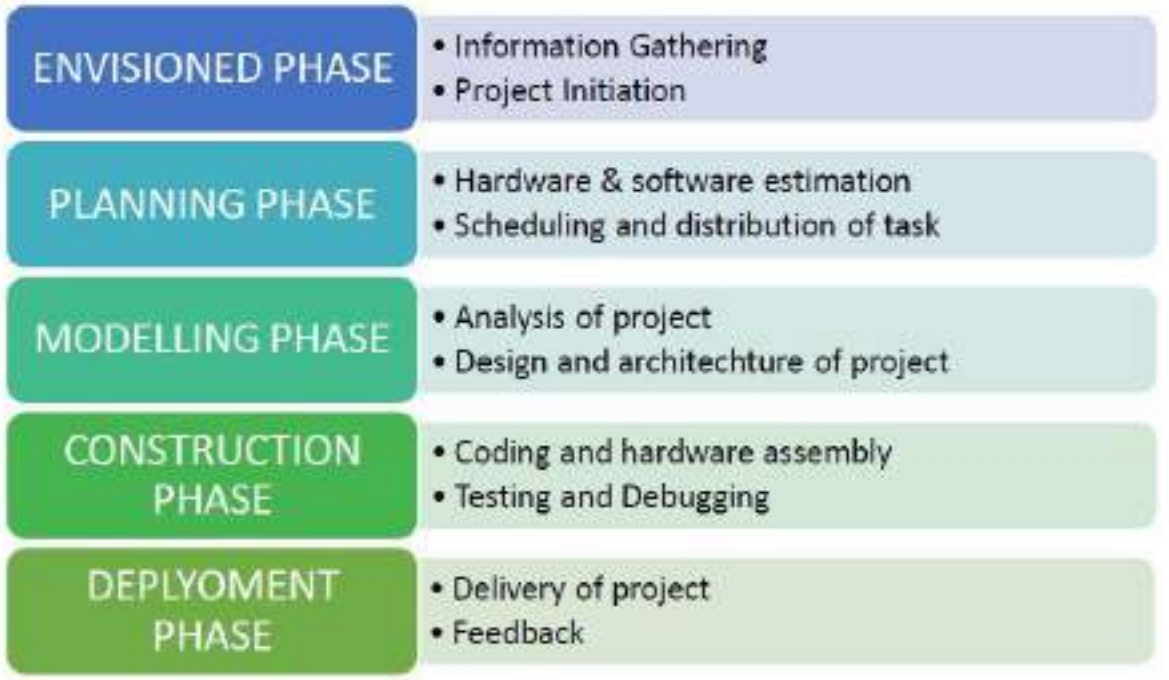


Figure13: Project management process

Experiment

During this stage of the project, we discussed the many pieces of essential equipment that would be required for the project. In order to acquire the essential theoretical understanding, we are going to examine many modern efforts that are linked to one another. In order to figure out the code, it is also important to build the whole process utilizing fundamental algorithms and flowcharts.

Design

The design team worked on the overall layout of the application as well as the functionality that was required to be included during this phase of the process. To achieve this objective, each of the components needed to be put together, and the application needed to be written.

Development and Testing

The application was crafted throughout this period of time. Flutter was used to make the connection between the Application device and the flask API, and the entire prototype was thoroughly tested to ensure that it was error-free.

Real world Testing

The prototype was ready to be put through its paces in the field and integrated with a wide range of electrical devices operating in real time.

4.11. Testing

Table 4.3: Test cases

Test Case: Create a new optimization Pre-Condition: Login to Carbonis application				
Test Case	Sequence	Test Description	Input Value(s)	Expected Result
1	1.1	verification	• Input optimization name • Input date • Input optimization gap • Click next button	Redirected to the next create page
	1.2	verification	• Add emission sources from drop down • Select emission factor for each source • Add constraints	Display threshold for each source

Test Case: Sent email alert to BA any violation of threshold Pre-Condition: Optimization should be created for relevant emission source				
Test Case	Sequence	Test Description	Input Value(s)	Expected Result
2	1.1	Verify whether emission exceeds the threshold or not	• Real time calculated emission value for each source • Optimum threshold	Get an warning email

4.12. Commercialization

Our primary audience for this research offering is comprised of commercial firms and sectors both domestically and internationally. In industrialized countries, all organizations are required to participate in efforts to reduce carbon emissions. Therefore, the majority of companies are looking for a reliable product. In industrialized countries, the market is filled with a lot of competition. Therefore, we need to entice them with a few different company techniques.

Carbon capture and storage, also known as CCS, has been recognized for a long time as one technology that has the potential to dramatically cut greenhouse gas emissions. The fundamental concept is to sequester carbon dioxide gas underground after it has been gathered. However, due to its high cost, CCS has not gained widespread adoption. However, giving the idea a new spin could result in a different cost structure. If carbon dioxide could be put to use in industry, the income that would be generated as a result may make carbon capture economically viable.

Already in operation are a few commercial applications for the utilization of captured carbon dioxide. The gas can be used, for example, in the production of chemicals and plastics, such as the polyurethane foams that are used for seat cushions. These foams are made from carbon dioxide in a plant that was just recently opened by Covestro, which was formerly known as Bayer Material Science. Research indicates that producing carbon fiber out of carbon dioxide gas might result in lower production costs compared to the conventional production method, which involves the use of polymers. However, the amount of carbon dioxide that might potentially be incorporated into chemicals, polymers, and carbon fiber would be between 40 and 90 million metric tons per year, which is insufficient to make a significant difference in the amount of greenhouse gas emissions that are produced globally. In order to contribute to a decrease in overall greenhouse gas emissions, carbon capture and use (CCU) techniques that absorb significantly greater quantities of carbon dioxide gas will be required.

The following are some effective marketing methods that might be utilized to commercialize this product:

- Develop a public relations and news media strategy.
- Develop a pricing strategy with packages.
- Use social media marketing strategies.
- Google ad-sense strategies.
- Arrange the events (virtual and in-person).

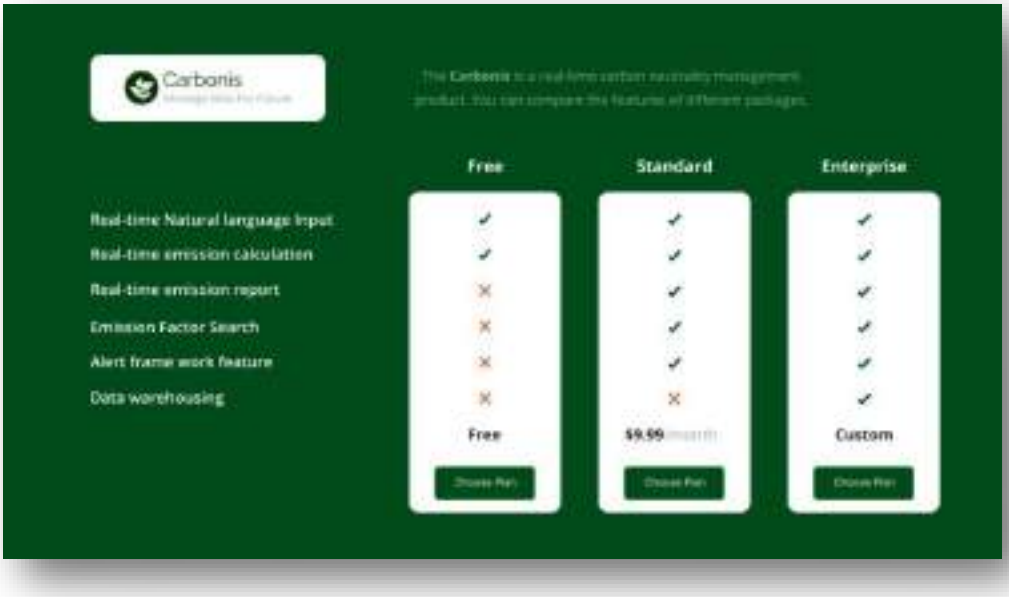
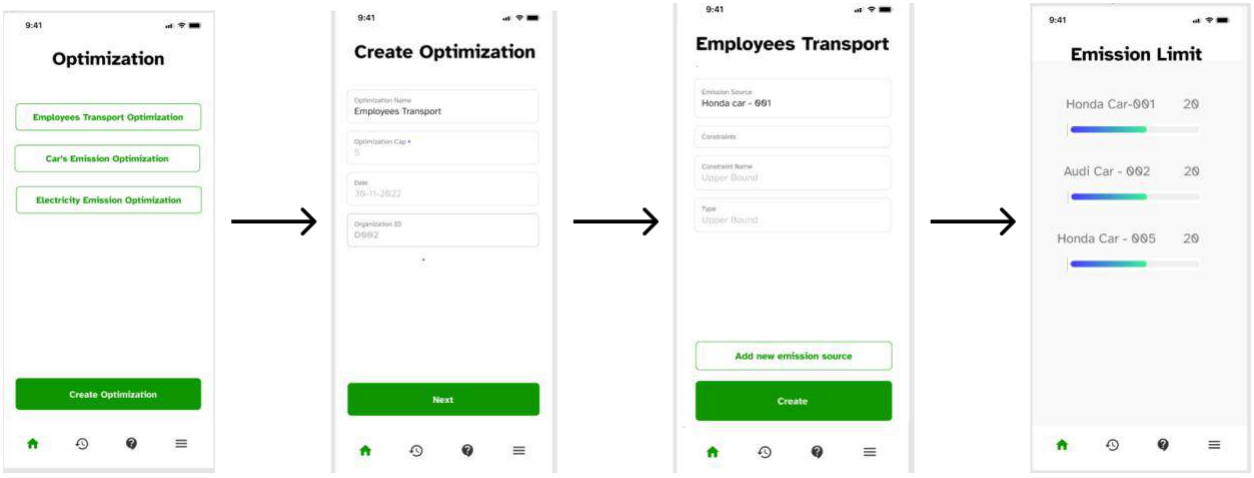
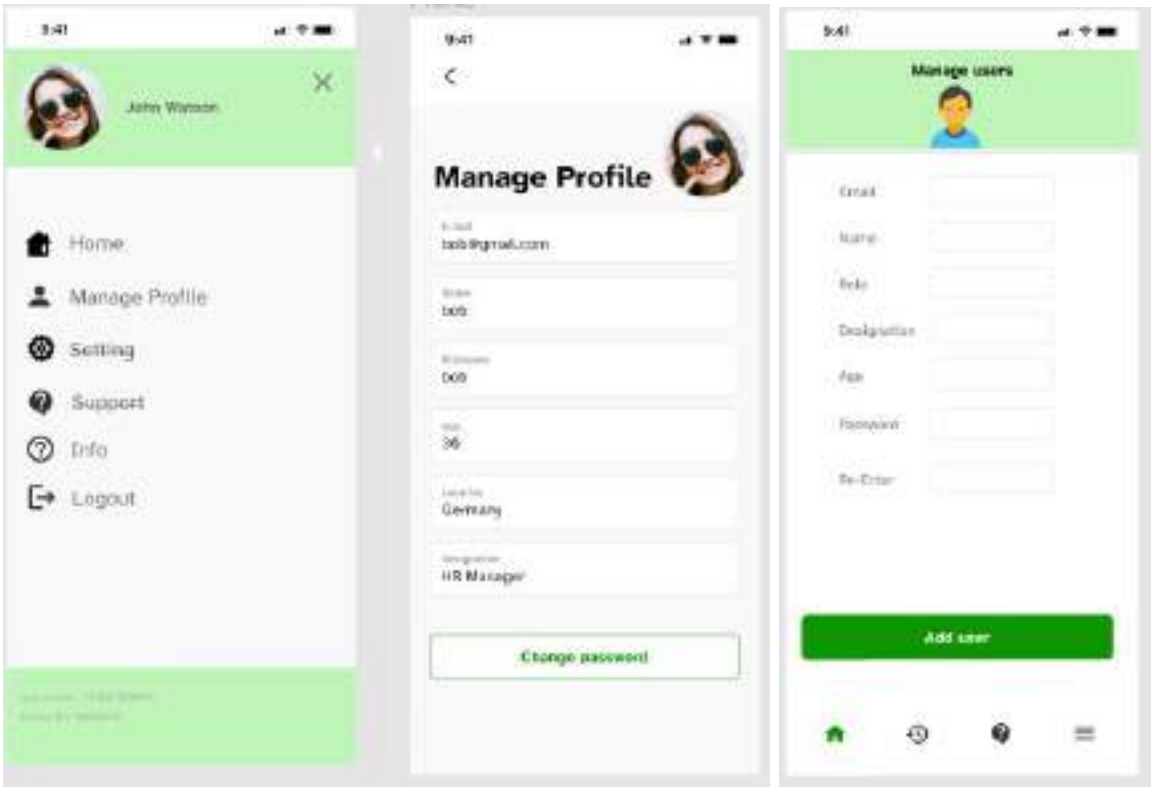


Figure 14: Revenue stream plan

Figure 15: Business model canvas

4.13. Interfaces





4.14. Coding

```
# checking emission type and calculate optimization
if (ty == 'transport'):
    for s in source:
        tsource.append(s)

    for t in tsource:
        for key in t:
            # bounds.append([t['min'], t['max']])
            if key == 'cf':
                tf.append(-1 * t[key])
                TF[s].append(t[key])

    result = linprog(tf, A_ub=TF, b_ub=[cap], method='interior-point')

    for x in result['x']:
        Tthresh.append(math.floor(x))

    for t in tsource:
        for key in t:
            if key == 'name':
                Tname.append(t[key])

    for i in range(len(Tname)):
        dictT[Tname[i]] = Tthresh[i]

    return dictT
elif (ty == 'electricity'):
    for s in source:
        esource.append(s)
```

```
    # optimization function
    result = linprog(of, A_ub=EF, b_ub=[cap], method='interior-point')

    for x in result['x']:
        Ethresh.append(math.floor(x))  # rounding the optimized value and storing in an array

    for e in esource:
        for key in e:
            if key == 'name':
                Ename.append(e[key])

    for i in range(len(Ename)):
        dictE[Ename[i]] = Ethresh[i]

    return dictE
elif (ty == 'others'):
    for s in source:
        osource.append(s)

    for o in osource:
        for key in o:
            if key == 'ef':
                of.append((-1 * o[key]))
                OF[0].append(o[key])

    result = linprog(of, A_ub=OF, b_ub=[cap], method='interior-point')

    for x in result['x']:
        Othresh.append(math.floor(x))
```

```
elif (ty == 'others'):
    for s in source:
        osource.append(s)

    for o in osource:
        for key in o:
            if key == 'ef':
                of.append((-1 * o[key]))
                OF[0].append(o[key])

    result = linprog(of, A_ub=OF, b_ub=[cap], method='interior-point')

    for x in result['x']:
        Othresh.append(math.floor(x))

    for o in osource:
        for key in o:
            if key == 'name':
                Oname.append(o[key])

    for i in range(len(Oname)):
        dictO[Oname[i]] = Othresh[i]

    return dictO
else:
    return 'Sopathing's wrong'
```


@app.route('/insert', methods=['POST'])
def insert_optimization():
inp = flask.request.json
print(flask.request.json)
Out = ''
if inp['type'] == 'Transport':
Out = optimize('Transport', inp['optimization_cap'], inp['unit'], inp['emissions'])
elif inp['type'] == 'Electricity':
Out = optimize('electricity', inp['optimization_cap'], inp['unit'], inp['emissions'])
print('Out', Out)
inp['Output'] = Out
print('inp', inp)
db.optimizations.insert_one(inp)
# print(user['name'],'Created successfully')
for i in Out:
if Out[i] > 445:
send_mail(i)
print(i,Out[i])
result = Out
return result

5. RESULTS AND DISCUSSION

5.1. Results

The findings of the research were summarized into three primary categories after being analyzed. System validity, carbon control, and the organizational structure of the business

A. Verification of the System

The blueprint for the system was well built so that it could successfully accomplish the necessary calculation and optimization of carbon emissions. The approach employed an algorithm that was unobtrusive enough to calculate the carbon emission and offer results in real time that had very accurate numerical values. In addition, both the front-end and back-end processes are formed by following the appropriate patterns and are accurately monitored by the user as well as the developer. In addition, because we stored the data on a cloud server, the real-time outputs were much simpler to handle and were much more sensitive to minute adjustments in the calibration. This results in a significant reduction in the amount of time needed to load the system and simplifies the overall experience for the user. Validation was performed using the appropriate settings and values for the current time period on the results and outcomes of the carbon neutrality tests as well as the data provided for optimizations.

B. Control of Carbon Emissions

The technique proved quite fruitful in terms of controlling the carbon emission produced by the organizations. The algorithm was designed to gradually lower the threshold by a smaller and smaller amount over the course of time. Consequently, it was graphed that the organizations' carbon emission will decrease with time in the next years. This results in the organization using fewer carbon credits overall, and it also reduces the amount of carbon that it emits. This leads to a reduction in the amount of carbon that is consumed by a certain percentage, and once the source of carbon emissions reaches its threshold, the system appears to follow an intelligent and sustainable path to function with no emissions of carbon due to the fact that carbon credits are reserved for a variety of important sources.

C. The Organization of a Company

The research, on the other hand, is supposed to concentrate on the management of real-time carbon neutrality and the optimization of climate circumstances; moreover, the central structure should produce a clean and successful business scheme that we may develop further. As a result, the cloud server storage and algorithm have the possibility of creating a business framework for the management of carbon control in organizations. With simply under the surveillance of BA, the entire carbon neutrality will be done and managed for the businesses, which boosts the efficiency and carbon waste management of the organization while simultaneously requiring less human labor. Because the machine language system provides an extremely accurate response to the optimization of real-time calculations, we are able to alter it to construct a comprehensive application geared toward the needs of businesses and huge institutions that generate a lot of traffic and use a lot of carbon. As a result of this research, a straightforward and easily digestible essential business structure in the field of carbon neutrality management has been produced.

5.2.Future Scope

In the future, we plan to gather more data, particularly for the unconstrained CO2 model, so that we may enhance the evaluation of the constrained models and possibly incorporate it during the training. This will allow us to collect more data for the unconstrained CO2 model. Specifically, our attempts to collect data will focus the majority of their attention on the leaf diseases that are not limited in any way. In order to get high accuracy, we might employ a variety of optimization approaches.

Even though we want to collect more data in an unrestricted context, information gathered in a restricted environment will still constitute the vast majority of our total data. As a consequence of this, one of our objectives is to enhance our grasp of the impact that the constraints imposed on the data collection have had on the generalization performance. If we take these actions, we will be able to improve the process of data collection, which will enable us to lessen the impact of any negative repercussions that may occur. In order to make the most of the chances afforded by the restricted data collection method, we plan to publish an app that will make it possible to collect data through the use of crowd sourcing.

6. CONCLUSION

The production of excessive amounts of carbon at this period of rapid modernization plays an essential part in the fight against climate change. The path that leads to a society that is more environmentally friendly is paved with the pursuit of carbon neutrality and the experimentation of environmentally responsible methods of its management. It was seen that there was a need for greater study in the application of carbon reporting at a corporate level, and the majority of the research that is now accessible focuses on the efficiency of various reporting schemes. The significance of this research lies in the fact that it seeks to improve carbon efficiency in order to conserve energy and lower undesirable emissions. Implementing a real-time platform that is able to provide insights into the organization's most recent emission statistics is one creative approach that has been proposed as a response to the issue that was described above. Assessing a company's carbon footprint is often the first step that businesses take on the path to becoming carbon neutral. By doing so, they will be able to determine the most effective strategic strategy to reducing emissions and setting lofty targets toward reaching carbon neutrality. The research was fruitful as it was written; nevertheless, there are a few recommendations that will make the research that comes after this paper more straightforward. One of the drawbacks of our research was that the user-provided data, such as limits and ranges, needed to be correctly supplied for the algorithm to respond to real-time improvement. The real-time technique was pretty precise to conventional optimization, which is the ideal practice that we propose for you to follow; however, it needs to be further enhanced for higher institutes while collecting data in bulk. To summarize, emission optimization for real-time carbon neutrality management can be carried out in a manner that is both very efficient and productive in the context of carbon control in companies.

References

[1] S. A. Sarkodie, P. A. Owusu, and T. Leirvik, "Global effect of urban sprawl, industrialization, trade and economic development on carbon dioxide emissions," *Environmental Research Letters*, vol. 15, no. 3, p. 034049, Mar. 2020, doi: 10.1088/1748-9326/ab7640.

[2] L. Niu, M. Pan, and L. Xiong, "Convergence analysis of urban green traffic carbon emission based on grey prediction model," *International Journal of Global Energy Issues*, vol. 42, no. 5/6, p. 285, 2020, doi: 10.1504/ijgei.2020.111180.

[3] B. Sarkar, M. Omair, and S.-B. Choi, "A Multi-Objective Optimization of Energy, Economic, and Carbon Emission in a Production Model under Sustainable Supply Chain Management," *Applied Sciences*, vol. 8, no. 10, p. 1744, Sep. 2018, doi: 10.3390/app8101744.

[4] T. Wiedmann *et al.*, "Three-scope carbon emission inventories of global cities," *Journal of Industrial Ecology*, vol. 25, no. 3, pp. 735–750, Sep. 2020, doi: 10.1111/jiec.13063.

[5] M. Roelfsema *et al.*, "Taking stock of national climate policies to evaluate implementation of the Paris Agreement," *Nature Communications*, vol. 11, no. 1, p. 2096, Apr. 2020, doi: 10.1038/s41467-020-15414-6.

[6] J. Bebbington and C. Larrinaga-González, "Carbon Trading: Accounting and Reporting Issues," *European Accounting Review*, vol. 17, no. 4, pp. 697–717, Dec. 2008, doi: 10.1080/09638180802489162.

[7] M. Y. Tay, A. A. Rahman, Y. A. Aziz, and S. Sidek, "A Review on Drivers and Barriers towards Sustainable Supply Chain Practices," *International Journal of Social Science and Humanity*, vol. 5, no. 10, pp. 892–897, 2015, doi: 10.7763/ijssh.2015.v5.575.

[8] K. Piper and J. Longhurst, "Exploring corporate engagement with carbon management techniques," *Emerald Open Research*, vol. 3, p. 9, May 2021, doi: 10.35241/emeraldopenres.14024.1.

[9] C. Quitmann, R. Sauerborn, and A. Herrmann, "Gaps in Reporting Greenhouse Gas Emissions by German Hospitals—A Systematic Grey Literature Review," *Sustainability*, vol. 13, no. 3, p. 1430, Jan. 2021, doi: 10.3390/su13031430.

[10] H. Hashim *et al.*, "An Integrated Carbon Accounting and Mitigation Framework for Greening the Industry," *Energy Procedia*, vol. 75, pp. 2993–2998, Aug. 2015, doi: 10.1016/j.egypro.2015.07.609.

[11] S. Tang and D. Demeritt, "Climate Change and Mandatory Carbon Reporting: Impacts on Business Process and Performance," *Business Strategy and the Environment*, vol. 27, no. 4, pp. 437–455, Dec. 2017, doi: 10.1002/bse.1985.

[12] Y. Lin and M. A. Stadtherr, "Advances in Interval Methods for Deterministic Global Optimization in Chemical Engineering," *Journal of Global Optimization*, vol. 29, no. 3, pp. 281–296, Jul. 2004, doi: 10.1023/b:jogo.0000044770.73245.14.

[13] Bibri, S.E. Smart Sustainable Cities of the Future: The Untapped Potential of Big Data Analytics and Context-Aware Computing for Advancing Sustainability; Springer: Berlin/Heidelberg, Germany, 2018.

[14] United Nations. United Nations Framework Convention on Climate Change; United Nations: New York, NY, USA, 1992.

[15] United Nations. Kyoto Protocol to the United Nations Framework Convention on Climate Change; United Nations: New York, NY, USA, 1998.

[16] The United States Congress. Global Change Research Act of 1990. 1990.

[17] United Nations. The Paris Agreement; United Nations: New York, NY, USA, 2015.

[18] ABB. White Paper on Electrification Carbon Neutrality— Electrification and Digitization Empower Low-Carbon Society; ABB: Västerås, Sweden, 2021.

[19] Yamano, N. and Guilhoto, J.: CO2 emissions embodied in international trade and domestic final demand. OECD, Paris, November 23, 2020.

[20] Sancino, A.; Stafford, M.; Braga, A.; Budd, L. What can city leaders do for climate change? Insights from the C40 Cities Climate Leadership Group net-work. Reg. Stud. 2021, 1–10.

[21] Laine, J.; Heinonen, J.; Junnila, S. Pathways to carbon-neutral cities prior to a national policy. Sustainability 2020, 12, 2445.

[22] Huovila, A.; Siikavirta, H.; Rozado, C.A.; Rökman, J.; Tuominen, P.; Paiho, S.; Hedman, Å.; Ylén, P. Carbon-neutral cities: Critical review of theory and practice. J. Clean. Prod. 2022, 341, 130912.

[23] Seto, K.C.; Churkina, G.; Hsu, A.; Keller, M.; Newman, P.W.; Qin, B.; Ramaswami, A. From low- to net-zero carbon cities: The next global agenda. Annu. Rev. Environ. Resour. 2021, 46, 377–415.

[24] Qi, J. Urban intelligence: Smart cities & the future of inclusive growth. Harv. Int. Rev. 2019, 40, 18–19.

[25] Lai, Y.; Yeung, W.; Celi, L.A. Urban intelligence for pandemic response: Viewpoint. JMIR Public Health Surveill. 2020, 6, e18873.

[26] Lai, Y. Urban Intelligence for Planetary Health. Earth 2021, 2, 972– 979.

[27] Velazquez, L.; Munguia, N.; Platt, A.; Taddei, J. Sustainable university: What can be the matter. J. Clean. Prod. 2006, 14, 810–819.

[28] Harangozo, G.; Szigeti, C. Corporate carbon footprint analysis in practice—With a special focus on validity and reliability issues. J. Clean. Prod. 2017, 167, 1177–1183.