PROJECT 3: CLIMATE CHANGE

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INTRODUCTION

Over the years, the world has been faced with severe climate changes due to the activities of human across the globe. Due to this, there have been unreliable crop yield massive droughts, flooding, and waning ecosystems. According to the Oxford dictionary, climate change refers to the change in global or regional climatic patterns, and it is usually attributed to the environmental factors such as increasing levels of carbon dioxide in the atmosphere, warm temperatures and the use of fossil fuel. Most of the world's major pollution that lead to tremendous increase in climate change comes from the developed and western countries. However, Africa, which contributes little to global warming faces the major consequences of climate change.

The goal of this project is to investigate the factors that affect climate change in the world using variables such as atmosphere, fossil fuel burning, terrestrial biosphere and the ocean. The effects that will be observed in the analysis in the form of models, differential equations, Matlab code and graphs will be used to investigate and conclude the impact of each of the climatic change factors.

CLIMATE CHANGE MODEL

SYSTEM DYNAMIC DIAGRAM

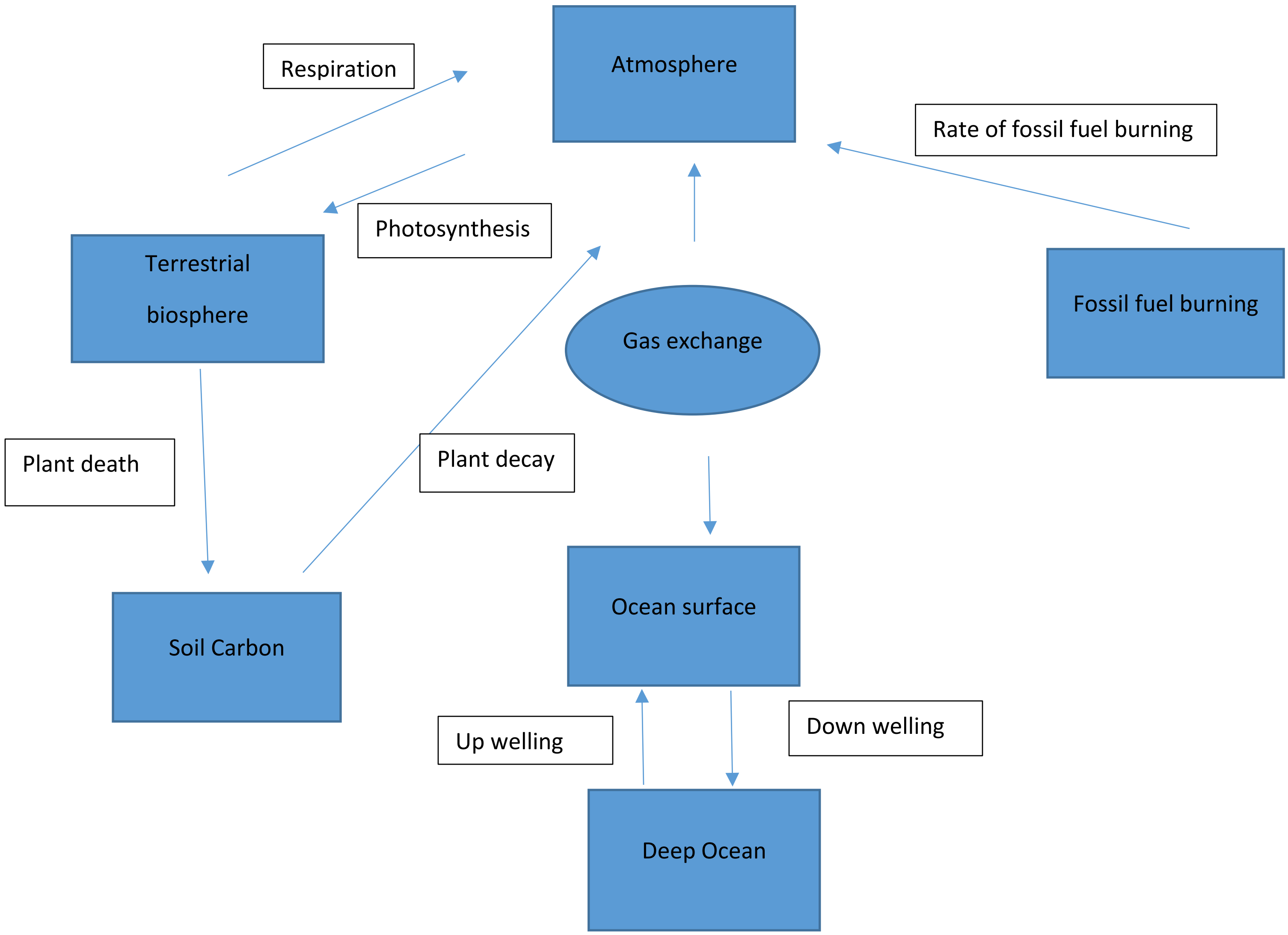

Figure 1. Shows the system dynamic diagram for the circulation of CO_2 in an ecosystem.

Explanation of the Model

The model shows the factors that affect the amount of carbon in the atmosphere. It can be observed that carbon is released into the atmosphere from the terrestrial biosphere, ocean surface, soil carbon and burning of fossil fuel. However, only photosynthesis and ocean surface can remove the amount of carbon from the atmosphere. This suggests that a large amount of carbon will be deposited into the atmosphere. The carbon released into the atmosphere originates from the deep ocean and it deposited or removed from the ocean through up welling and down welling respectively.

MATLAB CODE

```
% A model of carbon in the atmosphere

function dy = carbonModel

    function dydt = fxn(t, y)
        A = y(1);       % Atmosphere
        T = y(2);       % Terrestrial biosphere
        S = y(3);       % Soil carbon
        O = y(4);       % Ocean surface
        D = y(5);       % Deep ocean
        F = y(6);       % Fossil fuel
        Temp = y(7);    % Temperature of the atmosphere
        M = y(8);       % methane

        % initialise constants
        res = T*0.09565;            % respiration
        pd = T*0.09565;             % plant death
        rfb = 6*(1 + 0.14*t);       % rate of fossil burning
        pho = T*0.1913 + F*0.1;     % photosynthesis
        pdc = S*0.0392857;          % plant decay
        up = D*0.0007048;           % up welling
        do = O*0.03;                % down welling

        GE = (O-A)/75;              % gas exchange
        conc = A/2.12;
        CMeth = M;

        dMdt = 0.01*M*2.12;
        dFdt = rfb;
        dAdt = res + pd - pho + GE + F;
        dTdt = pho - res - pd;
        dSdt = pd - pdc;
        dOdt = up - do + GE;
        dDdt = do - up;
        dTempdt = 20+conc*0.01 + 21*(20+CMeth*0.01);

        dydt = [dAdt; dTdt; dSdt; dOdt; dDdt; dFdt; dTempdt; dMdt];
    end

    tspan = [0 40];

    Ao = 750;
    To = 575;
```

```
    So = 1400;
    Oo = 750;
    Do = 37600;
    Fo = 0;
    Temp_o = 25;
    Mo = 1.52;

    y0 = [Ao To So Oo Do Fo Temp_o Mo];

    [t, y] = ode45(@fxn, tspan, y0);

    figure(1)
    plot(t, y(:,1), t, y(:,2), t, y(:,4), t, y(:,3))
    legend('Atmosphere','Terrestial biosphere','Soil Carbon','Ocean surface')
    ylabel('CO2 amount (Gt.)')
    xlabel('Time (years)')
    grid on

    figure(2)
    plot(t, y(:,5))
    legend('Deep ocean')
    ylabel('CO2 amount (Gt.)')
    xlabel('Time (years)')
    grid on

    figure(3)
    plot(t, y(:,6))
    legend('Fossil fuel burning')
    ylabel('CO2 amount (Gt.)')
    xlabel('Time (years)')
    grid on

    figure(4)
    plot(t, y(:,7))
    legend('Atmospheric Temperature')
    ylabel('Temperature in Kelvin')
    xlabel('Time (years)')
    grid on

    figure(5)
    plot(t, y(:,8))
    legend('Methane')
    ylabel('Concentration of methane (ppm)')
    xlabel('Time (years)')
    grid on
end
```

GRAPHS OF THE MODEL

A GRAPH OF CARBON AMOUNT IN THE MODEL AGAINST TIME

A critical look at the graph below shows that the amount of carbon in the atmosphere has the highest rate increase with time. It rises from 750Gt. to 1123Gt. over 10 years. This is because the amount of carbon from the other stock variables such as surface ocean, terrestrial biosphere and soil carbon all flow into the atmosphere. The amount of carbon from ocean surface and terrestrial biosphere increase at a relatively slow rate over time. After 4years, the amount of carbon emission from terrestrial biosphere increases from 575Gt to 617Gt. But the ocean surface increases from 759Gt. to 772Gt. over a period of ten years. The amount of soil carbon has a slow rate of increase, that is, it increases slightly from 1400Gt. to 1411.6Gt.

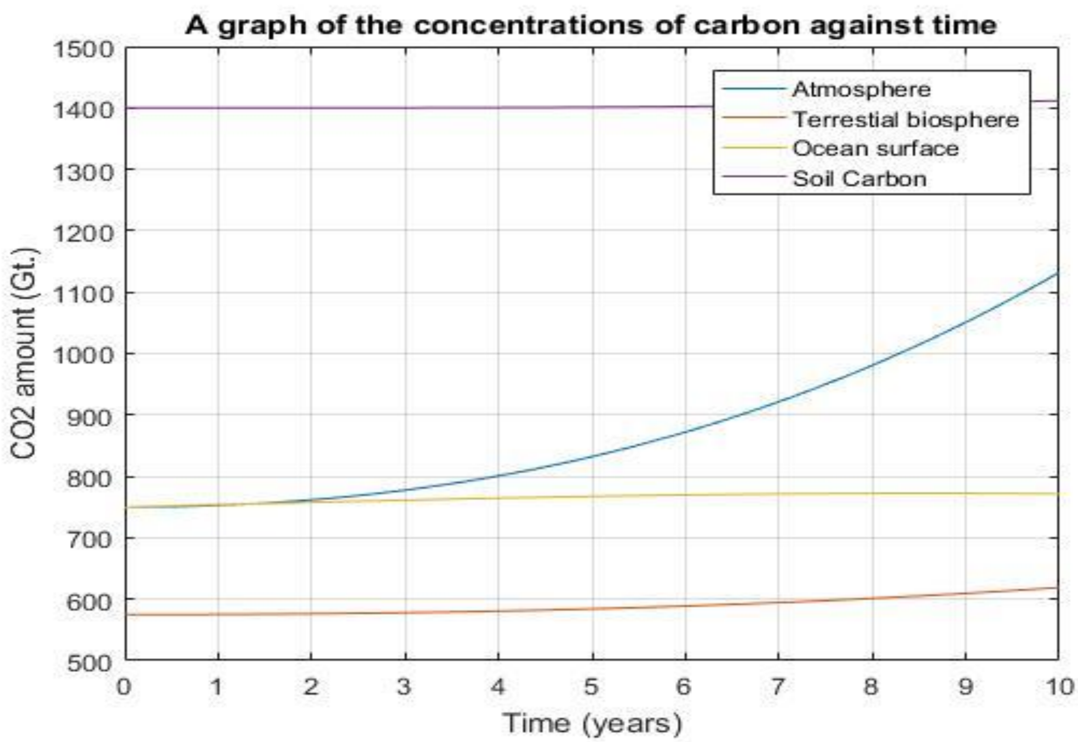

Figure.2 shows the graph of the amount of carbon in the various stock variables in the model over a period of 10 years.

DEEP OCEAN

The amount of carbon in the Deep Ocean decreases with increase in time. In the graph below, the initial amount of carbon decreases from 37600Gt. to 37560Gt. over a period of 10 years.

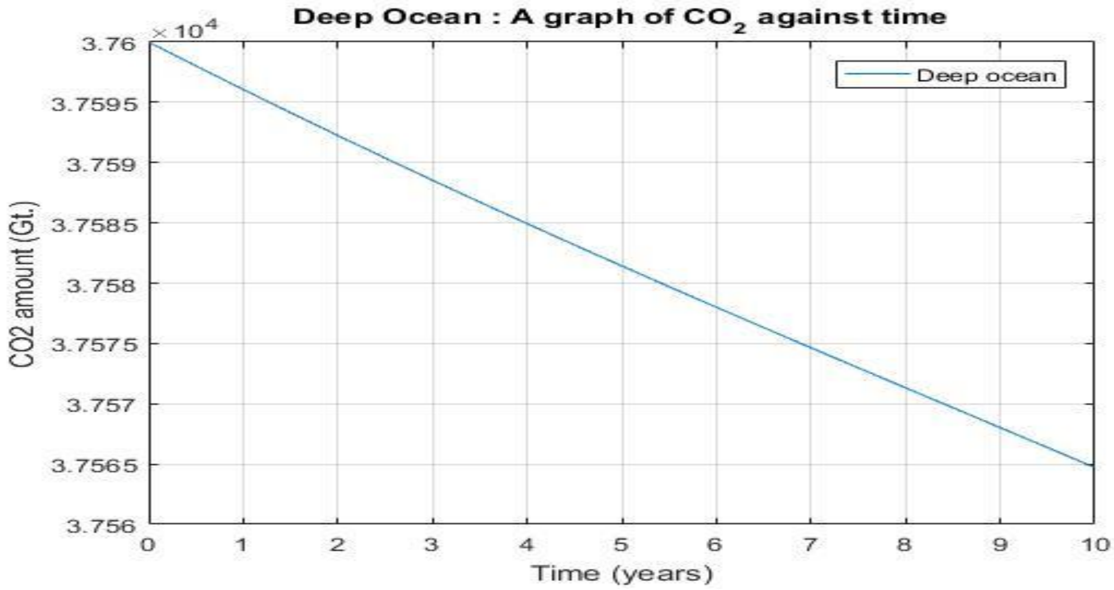

Figure 3 shows the graph of the amount of CO_2 in the deep ocean against time.

FOSSIL FUEL BURNING

The amount of carbon from fossil fuel burning increases along with time. In the graph below, it is seen that the amount of the carbon increases from 0Gt. to 100.6Gt over a period of 10 years.

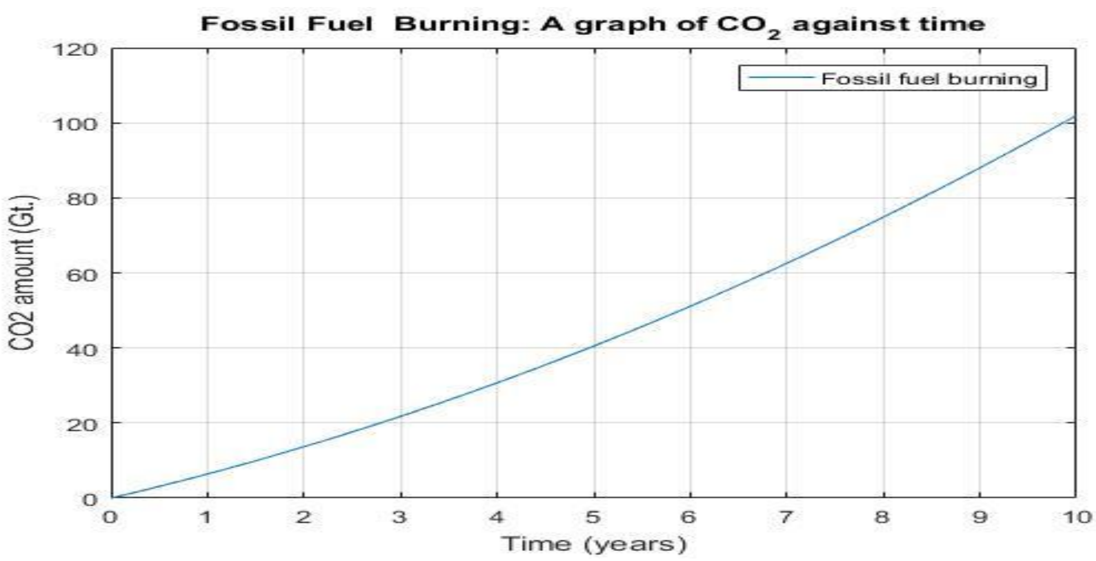

Figure 4. Shows the graph of amount of CO_2 from fossil fuel burning against time

ATMOSPHERIC TEMPERATURE

There is a proportional increase in temperature with time. The atmospheric temperature increases from zero to 4428.4K. in figure 5.

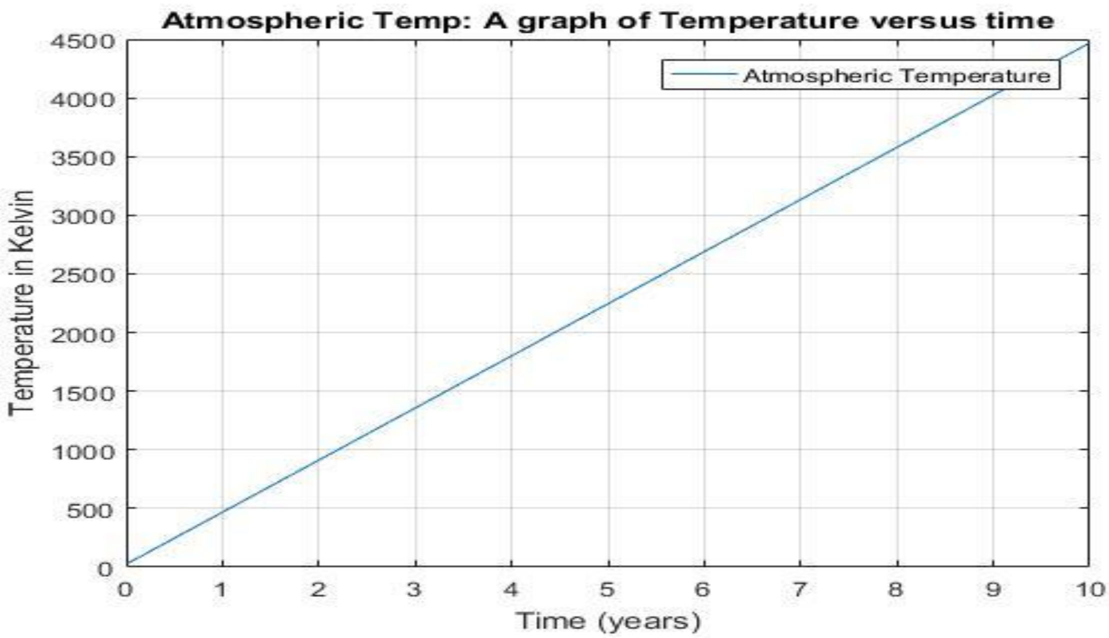

Figure 5. shows the graph of atmospheric temperature in Kelvin against time.

LONG TERM EFFECT OF FOSSIL FUEL BURNING

According to figure 4 and 5, the amount of carbon in the atmosphere keeps increasing with time in the long run. And there is also a correlation between the amount of carbon in the atmosphere and the temperature.

METHANE

The amount of methane increases along with time. The quantity of the methane increases from 1.574ppm to 1.58943ppm over a period of 10 years.

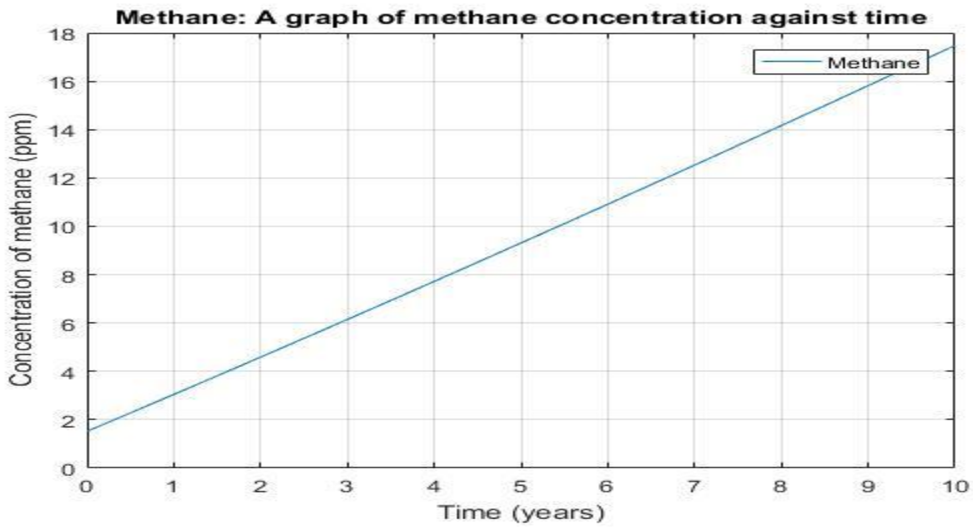

Figure 6. Shows the graph of amount of methane against time.

EFFECT OF CHANGING METHANE EMISSION.

It is seen from the graph below that the amount of methane increases along with time by increasing the rate. That is, the concentration of methane increases from 1.52ppm to 53.51ppm. This therefore results in an increase in the temperature of the atmosphere.

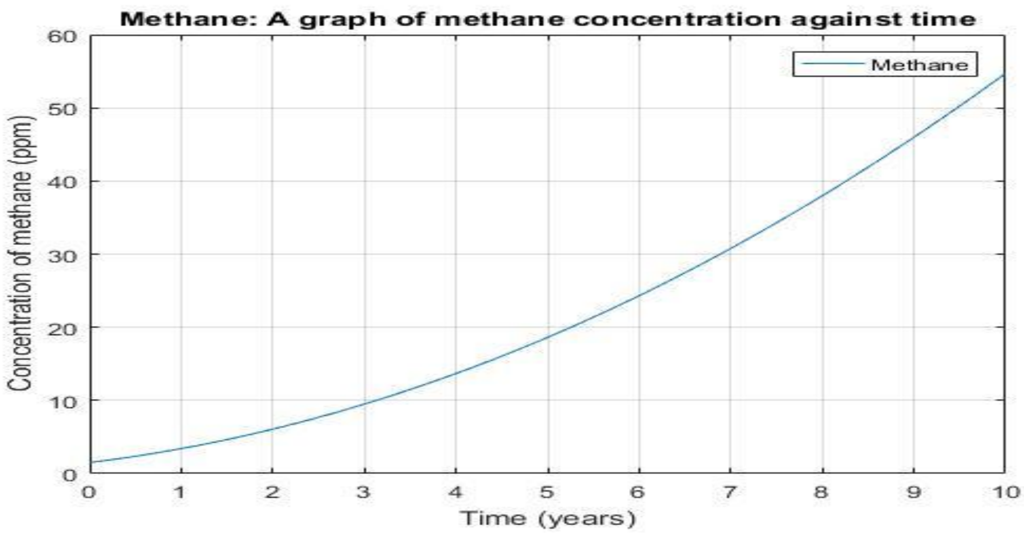

Figure 7. shows the effect of methane emission with time.

EFFECT OF NO FOSSIL FUEL BURNING IN THE MODEL

It can be observed from the graphs below that the amount of carbon in the atmosphere depends largely on the fossil fuel burning. This is because when the fossil fuel burning was removed from the model, the amount of carbon in the atmosphere reduced drastically as compared to the figure 1. which has fossil fuel burning. In figure 7. The amount of carbon in the atmosphere starts at 750Gt. and rises slightly above 750Gt. while the amount in the figure 1. begins from 1400Gt and increases to 1411Gt.

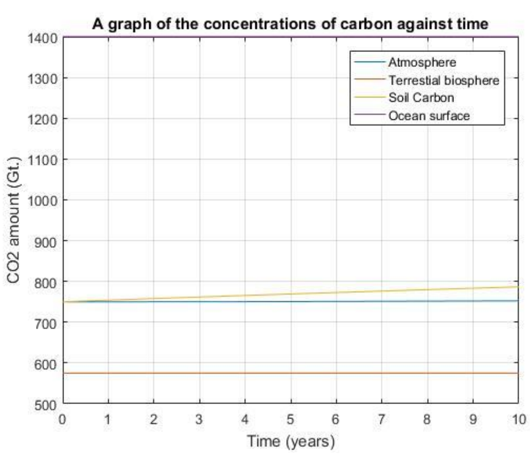

Figure.7

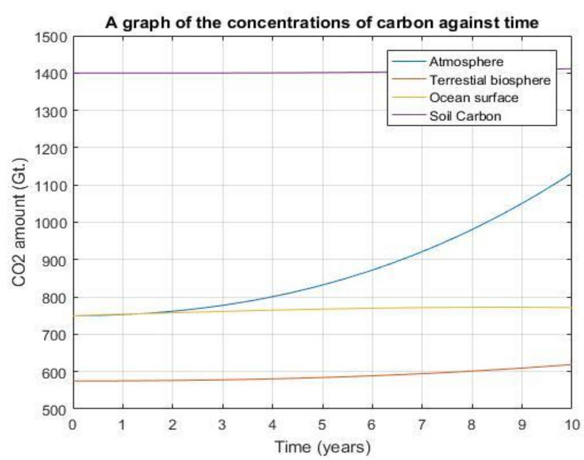

Figure 1.

Figure 8. shows the effect of no fossil fuel burning in the climate change model.

LIMITATIONS

The following are the limiting factors that were encountered in the course of the climate change model;

- Although the model throws more light on the increasing temperatures, it does not present information on flooding, periods of drought, or heat waves.
- Greenhouse effect gases such as water vapor, nitrous oxide, aerosol and Chlorofluorocarbons (CFCs) which causes climate change were specified or left out of the model.
- A discrete machine was used to model a continuous phenomenon.

CONCLUSION

Climate change is one of the main problems the world is fighting against because its consequences are detrimental to future generations. The climate change model investigated in this project shows the core factors that contribute to global warming. It is evident from the model that the activities of mankind play a huge role in increasing the amount of carbon in the atmosphere. This interesting model which was completed with Matlab software with its related graphs can go a long way in tackling the issues of global climate change. Although, the parameters involved in the projects are really good and they present information on increasing temperature along with time, it does not show the occurrence of disasters such as flooding, drought, and heat waves that causes bushfires.