

**Dr. Mohammad Shakil**  
**Department of Mathematics**  
**Miami-Dade College, Hialeah Campus**  
**1776 West 49th Street, Hialeah**  
**Florida 33012, USA**  
**E-mail: mshakil@mdc.edu**

## **SUSTAINABILITY: OUR ENVIRONMENT**

### **1. INTRODUCTION AND BACKGROUND**

“How can we apply Mathematics to the **“SUSTAINABILITY”** and **“OUR ENVIRONMENT?”**”

Definitions of sustainability in the context of our environment:

- “Sustainability is a paradigm or worldview that refers to the ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs” (Life Science: Sustainability of Ecosystems, <http://www.sasked.gov.sk.ca/docs/xsci/sexsc.html>).
- According to Worldwatch Senior Editor Thomas Prugh and Staff Researcher Erik Assadourian (2003), “Sustainability—the ability to meet our needs without compromising the ability of future generations to meet theirs—has become a catchphrase of the progressive sector. But in a world where populations continue to rise, the health of natural habitats are increasingly threatened, and economic inequalities grow, what will it take for the human race to not just survive, but thrive?”
- On the other hand, Newman and Kenworthy (1999) observe, “Sustainability is a state of dynamic equilibrium achieved by taking responsibility for balancing long-term economic environmental and social health. The concept of sustainability has emerged from a global political process that has tried to bring together, simultaneously, the most powerful needs of our time: (1) the need for economic development to overcome poverty; (2) the need for environmental protection of air, water, soil, and biodiversity, upon which we all ultimately depend; and (3) the need for social justice and cultural diversity to enable local communities to express their values in solving these issues” (Newman and Kenworthy, 1999, p. 4).

Sustainability of our environment is an issue of emerging international importance and significance. Since mid-1980s, considerable research into various aspects of issues related to environmental sustainability has been conducted. For example, the concentration of ‘greenhouse’ gases (namely, carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbon) in the earth’s atmosphere, resulting in a gradual increase in temperatures at the earth’s surface, is an important issue and area of research.

There is a rising trend of average global temperatures over recent years. Ecologists around the world are concerned about global warming. There are many causes and effects of such a global warming. One possible effect is the melting of the icecaps. According to the research, the scientists believe that the “greenhouse effect” may also be one of the causes of global warming. Smog and pollution in the atmosphere create a cover over the surface of the earth. The heat of the sun hits the surface of the earth and bounces off, but tends not to leave the surface because of the cover of pollution. Since 1959, the carbon dioxide content of the atmosphere has increased 13 %. The primary sources of this increase are the exhaust of automobiles, deforestation and other human activities.

Emissions of greenhouse gases worldwide resulting from the exhaust of automobiles, deforestation and human activities are expected to contribute to future climate changes. There is a number of potential impacts on the sustainability of ecosystems including warmer temperatures and rising sea levels, changes in rainfall patterns, and increased storm and cyclone intensity due to climate change. Consequently, these impacts are presenting many challenges for our world's environment, community and economy.

## **2. PROJECT – SUSTAINABILITY OF OUR ENVIRONMENT**

As my main concern was: “How can we apply Mathematics to the “**SUSTAINABILITY**” and “**OUR ENVIRONMENT**,” I came up with some projects on these topics (as described below) which I have already assigned to my classes, MAC 2233 (Business Calculus) and STA 2023 (Statistical Methods), during the current semester (Fall 2005).

### **(A)**

#### **Use of MINITAB: A Computer Project Assignment for STA 2023 Course**

- ❖ Note the data in the attached table regarding the concentrations of atmospheric carbon dioxide collected at Mauna Loa Observatory, Hawaii, and Cape Kumukahi, Hawaii, (see, for example, Goddard Institute for Space Studies (2002) and C.D. Keeling, T.P. Whorf, and the Carbon Dioxide Research Group (2002)). As greenhouse and climate change are fundamental issues of environmental sustainability, the purpose of this project is to study and conduct some statistical hypothesis test and construct confidence interval estimates of the difference between two population means based on independent samples of atmospheric carbon dioxide concentrations data from Mauna Loa Observatory and Cape Kumukahi, Hawaii.

#### **PROJECT**

- ❖ **Using the attached data, write a research project on the following topic:**
- ❖ **“TESTING HYPOTHESIS AND CONSTRUCTING CONFIDENCE INTERVAL ESTIMATES OF THE DIFFERENCE BETWEEN TWO POPULATION MEANS: AN ANALYSIS OF INDEPENDENT SAMPLES OF THE ATMOSPHERIC CARBON DIOXIDE CONCENTRATIONS DATA AT MAUNA LOA AND CAPE KUMUKAHI, HAWII”**

#### **DATA**

**TABLE 2.1**

<b>Year</b>	<b>Average Annual Carbon Dioxide Concentrations in parts per million (ppm) (Mauna Loa Observatory, Hawaii)</b>
<b>1972</b>	<b>327.46</b>

1973	329.68
1974	330.25
1975	331.15
1976	332.15
1977	333.90
1978	335.50
1979	336.85
1980	338.69
1981	339.93
1982	341.13
1983	342.78
1984	344.42
1985	345.90
1986	347.15
1987	348.93
1988	351.48
1989	352.91
1990	354.19
1991	355.59
1992	356.37
1993	357.04
1994	358.88
1995	360.88
1996	362.64
1997	363.76
1998	366.63
1999	368.31
2000	369.48
2001	371.02

**TABLE 2.2**

**Year Average Annual Carbon Dioxide Concentrations in parts per million (ppm)  
(Cape Kumukahi, Hawaii)**

1983	342.88
1984	344.53
1985	345.97
1986	347.47
1987	349.29
1988	351.68
1989	353.09
1990	354.91
1991	355.99
1992	356.67
1993	357.50
1994	359.38
1995	361.16
1996	362.97
1997	364.27
1998	366.82
1999	368.43
2000	370.13
2001	371.70

(Source: Goddard Institute for Space Studies, NASA Goddard Space Flight Center Earth Sciences Directorate, "Global Temperature Anomalies in .01 C," <http://www.giss.nasa.gov/data>, updated December 2002; C.D. Keeling, T.P. Whorf, and the Carbon Dioxide Research Group, "Atmospheric Carbon Dioxide Record from Mauna Loa," Scripps Institution of Oceanography, University of California, <http://cdiac.esd.ornl.gov/trends/trends.htm>, 13 June 2002.)

## RESULTS USING MINITAB

### Results for: CO2\_CONC\_Mauna\_vs.\_Kumukahi\_Hawaii.MTW

#### Descriptive Statistics: CO2\_CONC\_Mauna\_1, CO2\_CONC\_Kumukah

Variable	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median
CO2_CONC_Mauna_1	348.50	2.42	13.27	176.08	327.46	336.51	348.04
CO2_CONC_Kumukah	357.10	2.03	8.83	77.94	342.88	349.29	356.67

Variable	Q3	Maximum	IQR
CO2_CONC_Mauna_1	359.38	371.02	22.87
CO2_CONC_Kumukah	364.27	371.70	14.98

#### Two-Sample T-Test and CI: CO2\_CONC\_Mauna\_1, CO2\_CONC\_Kumukah

Two-sample T for CO2\_CONC\_Mauna\_1972\_To\_2001 vs CO2\_CONC\_Kumukahi\_1983\_To\_2001

	N	Mean	StDev	SE Mean
CO2_CONC_Mauna_1	30	348.5	13.3	2.4
CO2_CONC_Kumukah	19	357.10	8.83	2.0

Difference = mu (CO2\_CONC\_Mauna\_1972\_To\_2001) - mu  
(CO2\_CONC\_Kumukah\_1983\_To\_2001)

Estimate for difference: -8.59518

95% CI for difference: (-14.95151, -2.23885)

T-Test of difference = 0 (vs not =): T-Value = -2.72 P-Value = 0.009 DF = 46

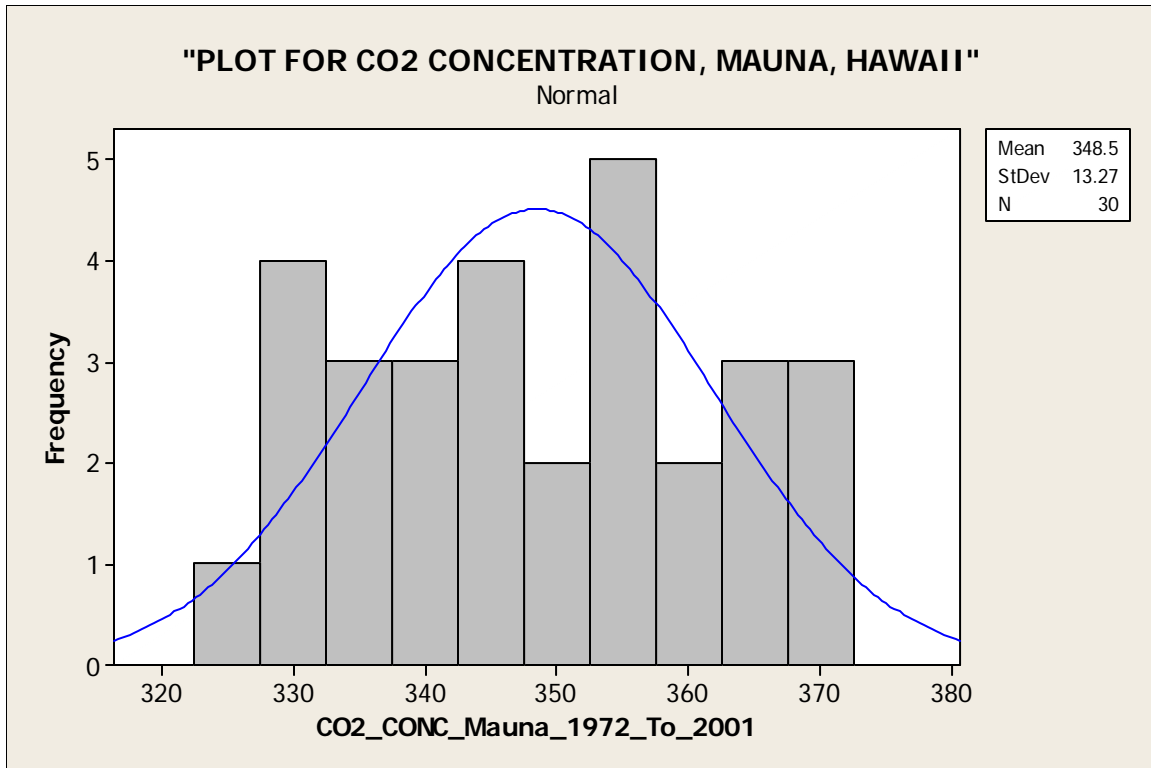


FIGURE 2.1

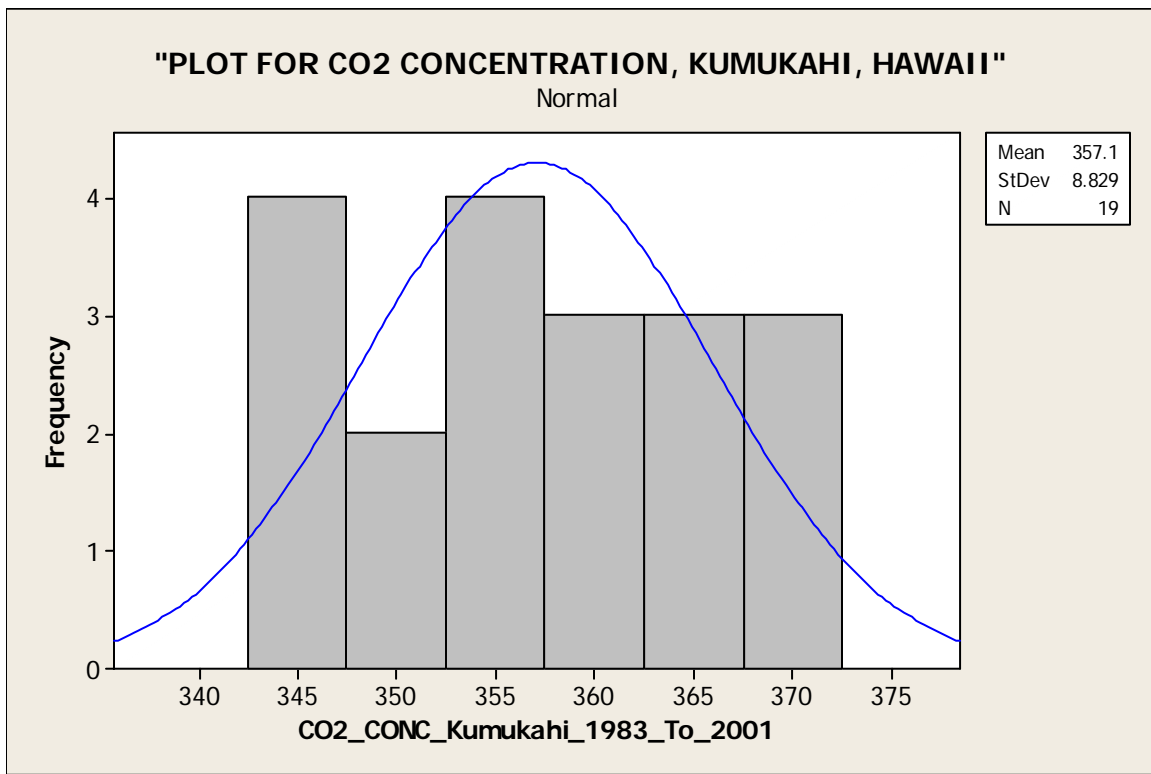


FIGURE 2.2

**(B)****Use of MINITAB and MAPLE: A Computer Project Assignment for MAC 2233 Course**

- ❖ Note the data in the attached table regarding the Global Average Temperature (in degrees Celsius) from 1950 to 2001, (see, for example, Goddard Institute for Space Studies (2002) and C.D. Keeling, T.P. Whorf, and the Carbon Dioxide Research Group (2002)). As greenhouse and climate change are fundamental issues of environmental sustainability, the purpose of this project is to study and analyze past trends in Global Average Temperature by applying some mathematical concepts from Business Calculus Course and using appropriate technology.

**PROJECT**

- ❖ **Using the attached data, write a research project on the following topic:**
- ❖ **“A STUDY OF PAST TRENDS IN AVERAGE GLOBAL TEMPERATURE FROM 1950 – 2001 BY APPLYING SOME MATHEMATICAL CONCEPTS FROM CALCULUS AND USING APPROPRIATE TECHNOLOGY”**

**DATA****TABLE 2.3****Global Average Temperature, 1950-2001**

<b>Year (x)</b>	<b>Temperature (degrees Celsius) (y)</b>
1950	13.83
1951	13.97
1952	14.04
1953	14.11
1954	13.91
1955	13.91
1956	13.83
1957	14.09
1958	14.09
1959	14.04
1960	13.98
1961	14.10
1962	14.05
1963	14.04
1964	13.76
1965	13.86
1966	13.93
1967	13.99
1968	13.90

1969	14.00
1970	14.05
1971	13.90
1972	13.95
1973	14.18
1974	13.94
1975	13.98
1976	13.78
1977	14.15
1978	14.07
1979	14.12
1980	14.27
1981	14.40
1982	14.09
1983	14.34
1984	14.16
1985	14.13
1986	14.18
1987	14.34
1988	14.42
1989	14.28
1990	14.49
1991	14.44
1992	14.16
1993	14.18
1994	14.31
1995	14.45
1996	14.34
1997	14.38
1998	14.69
1999	14.41
2000	14.38
2001	14.53

(Source: Goddard Institute for Space Studies, NASA Goddard Space Flight Center Earth Sciences Directorate, "Global Temperature Anomalies in .01 C," <http://www.giss.nasa.gov/data>, updated December 2002; C.D. Keeling, T.P. Whorf, and the Carbon Dioxide Research Group, "Atmospheric Carbon Dioxide Record from Mauna Loa," Scripps Institution of Oceanography, University of California, <http://cdiac.esd.ornl.gov/trends/trends.htm>, 13 June 2002.)

## RESULTS USING MINITAB AND MAPLE

TABLE 2.4

## RELATIVE EXTREMA OF GLOBAL AVERAGE TEMPERATURE

## USING MAPLE

```
> with(Student[Calculus1]):
CriticalPoints( -0.000006*x^3+0.000765*x^2-0.01290*x+14.01
);
```

```
[9.491162799, 75.50883720]
```

```
> extrema( -0.000006*x^3+0.000765*x^2-0.01290*x+14.01, { }, x
);
```

```
{13.95134695, 14.81452805}
```

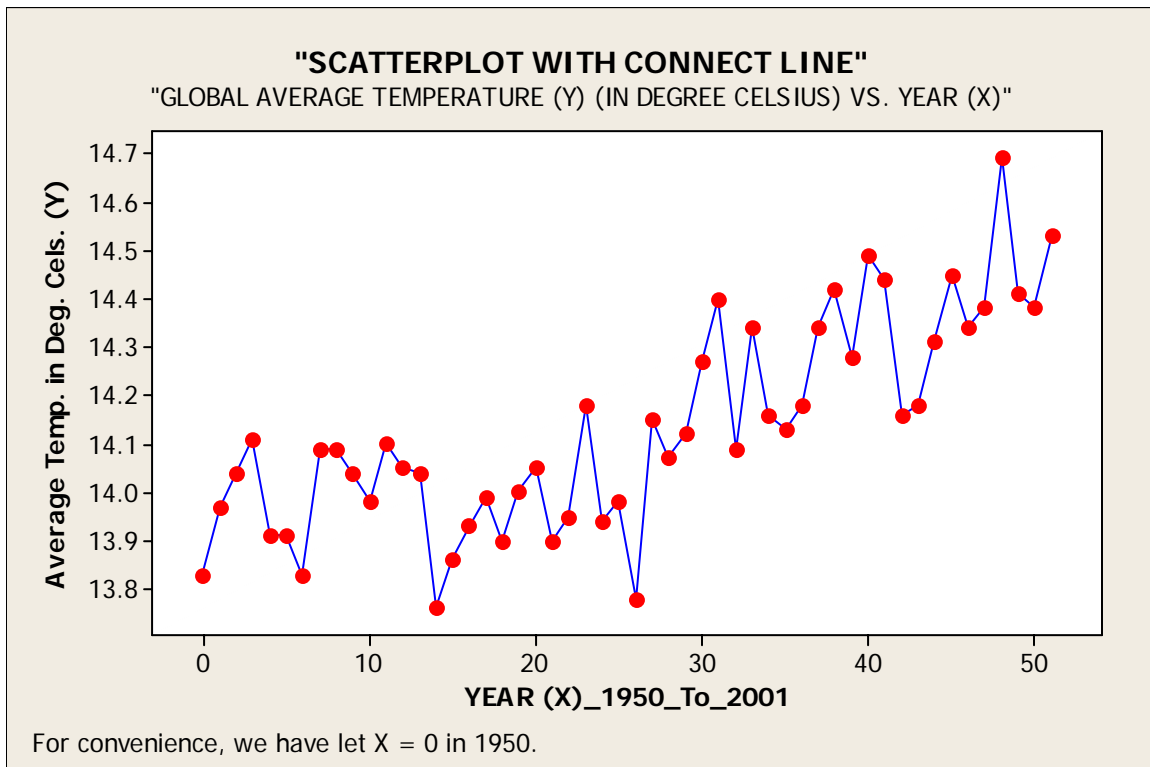


FIGURE 2.3

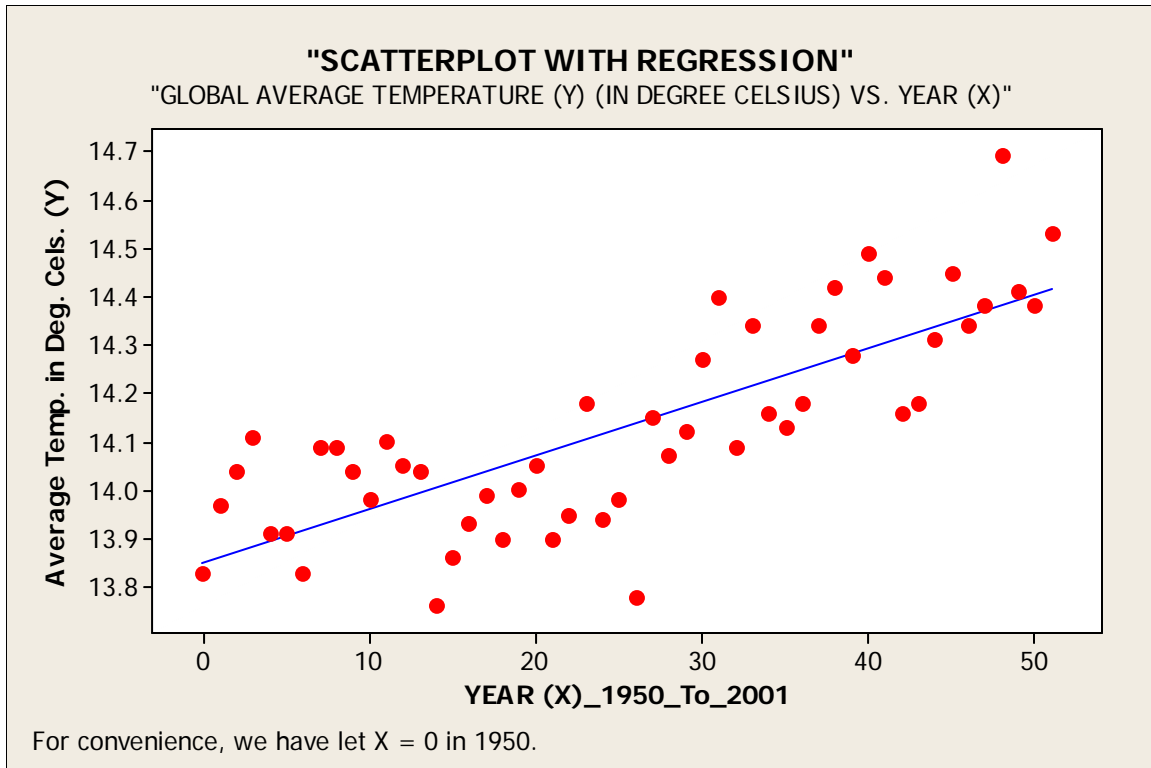


FIGURE 2.4

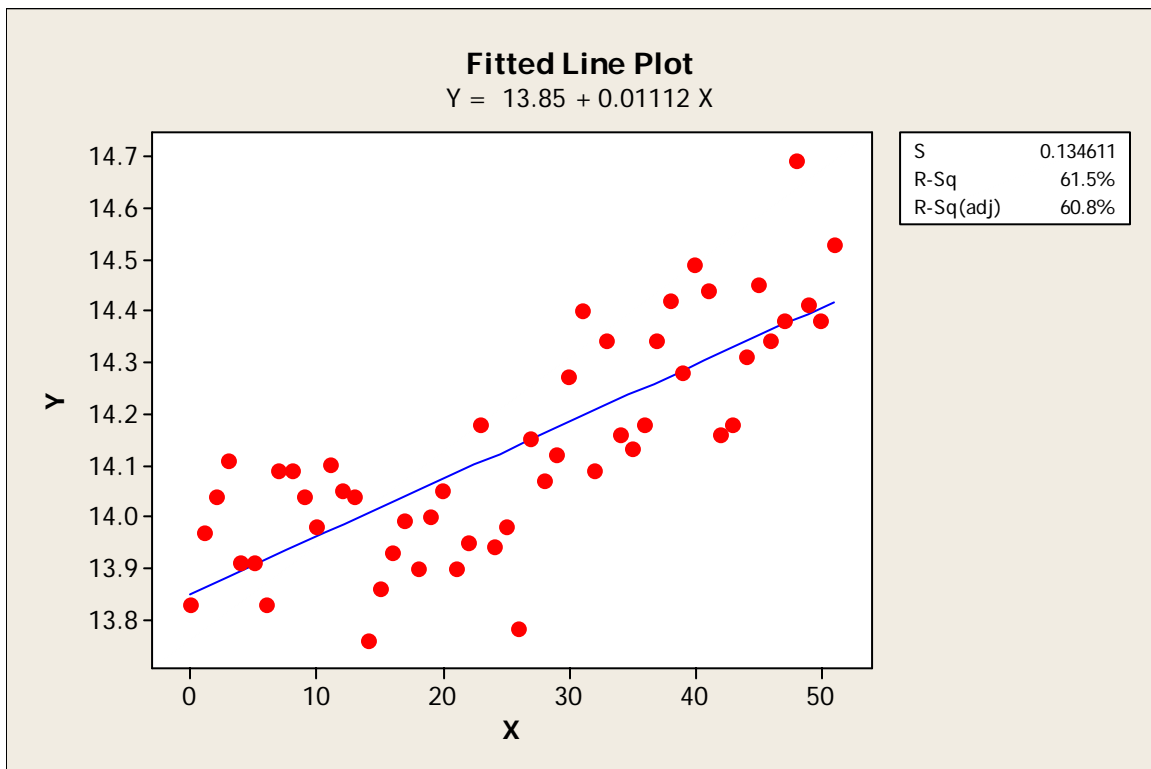


FIGURE 2.5

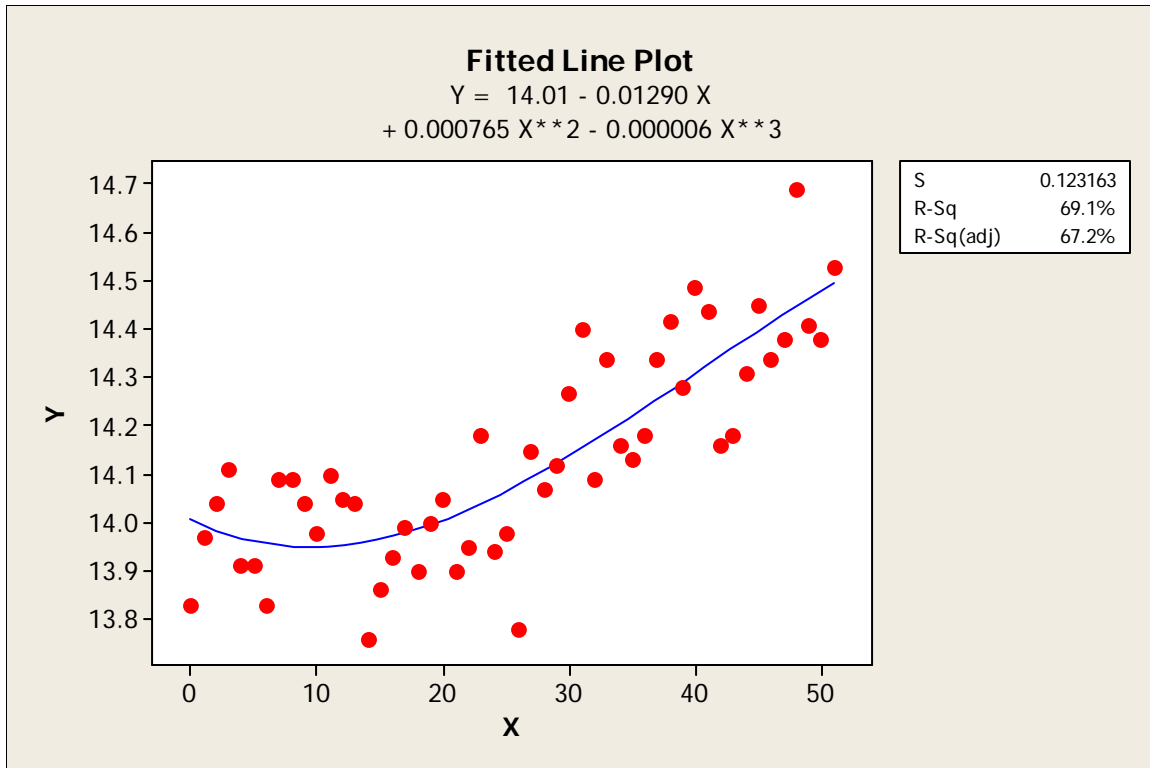


FIGURE 2.6

### 3. CONCLUDING REMARKS AND SUGGESTION

The students are successfully investigating the above projects. It should be noted that there are many aspects of “**SUSTAINABILITY**” and “**OUR ENVIRONMENT**” to which Undergraduate Mathematics can be easily applied. It is necessary that our mathematics students should be exposed to this important subject. As we always talk about the students’ lack of interest in mathematics, student success, QEP Mathematics, etc., it will be a great idea to introduce this important subject into our curriculum. At this point, I would like to take the opportunity to propose to the Earth Ethics Institute and to Miami-Dade College, in general, to develop a Center for Research, Studies and Training in Earth Mathematics (CRSTEM) under the auspices of Earth Ethics Institute. At CRSTEM, our students can attend some courses in Earth Mathematics. Our faculties and staff can also pursue their studies and research in this field of study. To my knowledge, there are very few such institutes for Earth Mathematics in the USA, or in the world. So, this will be an ideal and unique Center for Research, Studies and Training in Earth Mathematics at Miami-Dade College.

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- (9) C.D. Keeling, T.P. Whorf, and the Carbon Dioxide Research Group, "Atmospheric Carbon Dioxide Record from Mauna Loa," Scripps Institution of Oceanography, University of California, <http://cdiac.esd.ornl.gov/trends/trends.htm>, 13 June 2002.
- (10)[http://earthmath.kennesaw.edu/main\\_site/precalculus/precalc\\_conc.htm](http://earthmath.kennesaw.edu/main_site/precalculus/precalc_conc.htm)