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Assessing the Actual Performance of Green Buildings in Palestine: A Case Study

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This thesis was successfully defended on 6/5/2018 and approved by:

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Dedication

I dedicate this work to my precious family, friends and colleagues whose patience, continuous prayers and perseverance led me to this accomplishment.

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A lot of thanks

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل عنوان

Assessing the Actual Performance of Green Buildings in Palestine: A Case Study

أقر بأن ما اشتملت عليه هذه الرسـالة إنما هو نتاج جهدي الخاص، باسـتثناء ما تمت الإشـارة إليه حيثما ورد، وأن هذه الرســـالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted by others elsewhere for any other degree or qualification.

Student Name: **اسم الطالب: حاتم غالب الحضيري**

Signature **التوقيع:**

Date **التاريخ:**

Table of Contents

List of Figures

List of Tables

List of Appendix

Abbreviation Table

Abbreviation	**Description**
BEI	Building Energy Index
CI	Confidence Interval
GBI	Green Building Index
GEEBD	Guideline for Energy Efficient Building Design
ILS	Israeli Shekels
IQR	Interquartile Range
kWh	Kilo Watt Hour
kWp	Kilo Watt Peak
LEED	Leadership in Energy and Environmental Design
n	Sample Size
PHGBC	Palestine Higher Green Building Council
PV	Photovoltaic
Q1	The First Quartile
Q2	Median
Q3	The Third Quartile

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Abstract

There is evidence indicates that buildings often do not perform as expected in terms of energy and water consumption. Nowadays, this issue is becoming one of the main topics that is being discussed and studied with increasing attention. The main aim of this research is to assess the actual economic performance of the first green school in Palestine, which is Aqqaba Green School, in terms of energy and water consumption, then, to quantify the actual energy and water saving compared to other schools in Palestine. This research also aims to investigate whether the actual performance of the green school meets the anticipated performance in the design simulation or not. A performance measurement baseline was established using data collected from actual energy and water consumption reports, as well as actual energy and water costs for a sample consists of 205 governmental schools in West Bank for the year 2016. The data of annual energy and water consumption were ordered in an ascending order, then, five number summary analysis was applied to calculate interquartile ranges and interquartile intervals which allows excluding the outliers and hence reduce the variation between the data, then, the mean value of the remained data was calculated and considered as the baseline. It is statistically found that the baseline of the annual energy consumption of schools in the sample is 10,639 kWh/year which corresponds to a building energy index (BEI) of 9.56 kWh/m^2/year, while the annual energy consumption of the green school is 10,124 kWh/year, which corresponds to a building energy index (BEI) of 7.19 kWh/m^2/year. It is found that, in its first year of operation, the green school has generated more energy than its consumption by 4,426 kWh/year which yields an annual income of 2,297 ILS/year. In term of water consumption, it is found that the baseline of annual water consumption of schools in West Bank in Palestine is around 450 m^3/year which corresponds to 1.25 m^3/student/year, while the annual water consumption of the green school is 460 m^3/year, which corresponds 2.95 m^3/Student/year. It is also found that the actual energy performance of Aqqaba Green School is 7.19 kWh/m^2/year in its first year of operation, which corresponds to 11.79 % of the anticipated performance in the design simulation which is around 61 kWh/m^2/year. As a conclusion, the actual energy performance of the green school in its first year of operation is much lower than the predicted consumption in the design stage, while the actual energy performance of the Green School was close to the developed baselines.

Chapter One

Introduction

Chapter One

Introduction

1.1 Overview

Over the past years, the concern about the implementation of sustainability and sustainable development has drastically increased (Silvius & Schipper, 2014). The term “sustainable development” was first introduced in Brundtland's Commission Report in the year 1987, which defined sustainable development as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In addition, the report played a vital role in transforming sustainability from a theoretical term related to ecology and green to an empirical term used in projects (Okland, 2015).

One of the most important applications of sustainable projects is the green building, which is defined from the perspective of Kibert (2007) as "the outcome of applying sustainable construction approaches to create a responsibly built environment is most commonly referred to as high – performance green buildings, or simply, green buildings". In order to consider any building as sustainable or green, that building should meet the requirements of international or local green buildings criteria, which include, but are not limited to sustainable sites, water efficiency and energy saving (Boarin et al., 2014).

In Palestine, the concern about implementing the concept of green buildings is increasing. Since Palestine has limited control over energy and water resources due to the political complications, the Palestinian construction sector should move towards constructing green buildings. The reason for this step is that one of the significant benefits of green buildings is to use the available resources in an efficient method, both during building construction and building operation (PHGBC, 2013).

However, several research papers highlighted that buildings in general suffer from mismatch between the actual and the predicted energy consumption levels due to the lack of the accuracy of simulation results and the absenteeism of energy controlling rules (Tunner & Frankel, 2008; De Wilde, 2014; Menezes et al., 2012). Demanuele et al. (2010) claimed that buildings in general do not perform as expected. Such difference between the expected performance and the actual performance is referred to as "performance gap".

According to Ward (2015), performance gap is defined as the difference between the actual performance or the actual situation with the planned or the designed situation. The reasons for such gap include lack of energy management policy and poor understanding of building control systems, especially in understanding the use of control systems that use energy for heating and cooling purposes (Lewry, 2015).

1.2 Problem Statement

In the light of the previous arguments, this research addresses the issue of performance gap in Palestine by measuring the actual performance of the first certified green school in Palestine by the Palestinian Green Buildings Council, which is Aqaba Green School. As the first certified green school in Palestine, it is essential to measure the actual performance of the school to see how the green school performs in comparison to conventional (non-green) schools. It is also imperative to quantify the actual economic benefits related to energy consumption, which will in return provides empirical evidence for the actual economic benefits which are quantified based on the actual performance instead of relying on simulation.

1.3 Research Questions

The research questions were derived from the problem statement; this research is designed to answer the following questions:

1- Does the actual energy performance of Aqqaba Green School meet the anticipated energy performance in the design simulations?

2- How much is the actual energy and water saving in Aqqaba Green School compared to the baseline energy and water consumption in other schools in West Bank in Palestine?

3- How much is the actual cost saving in energy and water consumption compared to the industry baseline?

1.4 Research Objectives

The main objective of this research is to assess the actual economic performance of Aqqaba Green School in terms of energy and water consumption, in order to quantify the actual economic benefits compared to other schools in Palestine. Other objectives of this research are:

- To compare between the actual energy performance of Aqqaba Green School with the predicted energy performance in the design simulations.
- To compare between the actual energy and water consumption of Aqqaba Green School with the baseline in West Bank in Palestine.
- To quantify the actual economic value resulting from the actual energy and water savings in Aqqaba Green School.

1.5 Significance of the Research

This research provides an empirical evidence about the actual performance of a Palestinian green school, Aqqaba Green School, in terms of energy and water consumption. In addition, this research established a baseline which the practitioners could us to assess the performance of other Palestinian green schools. Furthermore, this research will track and measure the economic benefits gained from the existing PV system installed in the green school.

1.6 Thesis Structure

This thesis consists of five chapters; Chapter One provides an introduction to the problem statement, definition of the problem statement, research questions, research objectives and the significance of the study. Chapter Two presents literature review related to green buildings, the actual performance of green buildings, assessment methods and tools used to assess the performance of green buildings. Chapter Three summarizes the research methodology. Chapter Four presents the results of data collection and data analysis. Chapter Five presents the conclusion of the research and recommendations for future work.

Chapter Two

Literature Review

Chapter Two

Literature Review

In this chapter, literature review will provide and present an overview about green buildings and about the most common methods of assessment used to assess the performance of such buildings based on specific rating systems and based on the actual performance of these buildings.

2.1 Green Buildings

The term “green building” first appeared in the 1970’s as a reaction to the need of energy efficiency and sustainable buildings (Yu & Kim, 2011), and until this day, the awareness about the importance of this topic is increasing (Silvius & Schipper, 2014). The subject of green buildings was considered in the agenda of the United States for more than forty years, since Stockholm conference in 1972 (Sachs, 2015) and after oil crisis in the 1970’s (Feng, 2011).

According to Dwaikat & Ali (2016), in order to consider any building as sustainable, that building should maintain a group of environmental aspects and characteristics during the stages of its construction, operation, disposal and recycling.

In addition to the aspects of sustainability, green buildings have additional aspects that lead to increase the efficiency in the usage of water and electricity, reduction in the consumption of natural materials and resources, in addition to improving indoor health and air quality (Laustsen, 2008).

According to PHGBC (2013), since Palestine is a country under occupation and has limited control over the available natural resources, and since one of the aims of constructing green buildings is to use the available resources efficiently, the Palestinian construction sector should follow sustainability guidelines throughout different stages of construction, and Aqqaba Green School is considered an example of green buildings in Palestine.

Since the terms “green” and “sustainable” are used as synonyms in this field, the term “green building” has the same indications as terms including high performance buildings, green construction, sustainable buildings and sustainable construction, and based on these terms, green buildings have different definitions.

In existing literature, there are many definitions of green buildings. The first definition provides an image that such green buildings consist of a hut made of woods, or a roof that contains with lawns and solar panels (Izvekova et al., 2016). However, when it comes to the true definition of a green building, Kibert (2013) defined it as a building designed and constructed with environmentally-friendly basics and whose resources were used efficiently. Yudelson (2008) believes that a green building is the building that has high – performance and has minimal effect on the humanity and on the environment. In addition, the US Environmental Protection Agency (EPA, 2016) defined green building as “the practice of creating structures using environmentally responsible processes throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction”. Najib et al. (2016) argued that “green” is a general term that describes sustainability or development for a building. Another general definition of green buildings is the definition provided by Steinmann et al. (2016), which defined green buildings as “structures designed to promote efficient use of resources and sustainability”.

According to the definitions provided above, there are many purposes for constructing green buildings. For example, a study conducted by Kubba (2010) argued that the main purpose of designing green buildings is to reach the optimum energy efficiency, while providing more comfortable, healthier and productive indoor environments for the occupants of green buildings by maximizing the efficient usage of resources like energy and water. Additional aims of constructing green buildings include reducing the negative effect on the climate and on nature. (Krizmane et al., 2016; Cidell, 2012).

Li & Wang (2016) stated four additional main purposes for such buildings including the elimination of environmental impacts, substitution of the traditional process with environmentally friendly technologies, developing new techniques for more engineering control, and finally, developing efficient environmental system for better administration controls.

Based on the arguments above, and since the main aim of constructing green buildings is the efficient use of the available energy and material resources, there are many arguments claimed that the construction sectors suffer from extra energy consumption problem. For example, Zhao et al. (2016) argued that buildings are directly responsible for about 41% of the main energy consumption in the USA, and also, the researchers mentioned that 356

Billion kWh of electric power are consumed for heating and cooling purposes. This consumption of electricity represents over 30% of the total electricity consumption in USA houses, and after applying green building standards, 43% of the total energy consumption could be reduced.

Similarly, Abu Bakar et al. (2015) provided some evidences that the construction sector is considered the largest energy consuming sector in different countries. For example, building sector consumes around 40% of the total energy consumption in Europe (Zhao & Magoules, 2012), 23% in Spain (Perez-Lombard et al., 2008), 25% in Japan (Gyn-Young et al., 2005), 28% in China (Lam et al, 2006), 30% in United Kingdom (Perez-Lombard et al, 2008), 42% in Brazil (Delbin &Vanessa, 2005), 50% in Botswana (Sukri et al., 2012) and 47% in Switzerland (Zimmermann et al., 2005).

In contrast to the results attained through conventional construction, there are many studies indicating that green buildings lead to a reduction in energy and water consumption levels. According to Kats et al. (2003), green buildings could save cost and energy on the long run by 30% on average. Also, Madew (2006) argued that according to the Australian and worldwide case studies, 60% of water consumption could be reduced. In Addition, Yudelson (2008) mentioned that these buildings typically could provide around 30%-50% savings in water and energy consumptions.

2.2 Assessment of Green Buildings Using Rating Systems

Building Assessment Systems can be defined as rating tools used to assess buildings based on how these buildings deal with the environmental, social and economic concerns compared to the ultimate goals that should be achieved (Ding, 2005).

The purpose behind establishing such assessment systems was to develop unified standards for green buildings to be used in the assessment process of the performance of green buildings based on certain criteria (Retzlaff, 2008). The most common form of a traditional building assessment is a rating tool that consists of a checklist that contains specific items assessed by assigning specific marks based on the importance of each item. These items usually include energy efficiency, water conservation and indoor environmental quality (Papamichael, 2000).

In the last few decades, the first impression about building rating systems from the view of builders and architects is that such rating systems focus solely on the impact of construction projects on the environment, and they believe that these rating systems should be developed to tackle sustainability issues (Cole, 2005). According to Lutzkendorf and Lorenz (2006), the history of developing building assessment systems was divided into four main stages. The first stage is concerned with assessing buildings based on the cost of their construction. The second stage added environmental aspects and technical solutions to the assessment system. In the third stage, building assessment systems transformed from depending solely on the aspects of green buildings on the assessment method to depending on the aspects of sustainable building. The fourth and the final stage is expected to overcome sustainable building and to use multiple items as an integrated system.

Moreover, the researchers suggested that building assessment systems implemented today lays between the third and fourth stages.

Since October 2016, 145,000 buildings were officially certified as green buildings around the world (Steinemann et al., 2016). Nowadays, there are over 31 green building certification programs around the world, and each country has its own green building council and its own rating system. For example, in the United States, the American Leadership in Energy and Environmental Design (LEED) is used in rating green buildings. In the United Kingdom, British Research Establishment Environmental Assessment Method (BREEAM) is used to rate green buildings (Izvekova et al., 2016). Also, LEED-Italia is used as a rating system in Italy (Boarin et al., 2014). In addition, Comprehensive Assessment Scheme for Built Environment Efficiency (CASBEE) and Sustainable Building Assessment Tool (SBAT) are used as a rating tool in Japan and South Africa respectively (Malley et al, 2014). In Palestine, there is the Palestinian Higher Green Building Council, which evaluates green buildings based on its own guidelines related to green buildings.

One of the most effective rating tools used worldwide is known as Leadership in Energy and Environmental Design (LEED). It was issued by the United States Green Building Council. The LEED assesses green buildings based on six criteria which are: Site sustainability, Water efficiency, Energy and Atmosphere, Materials and resources, Indoor Environmental and Innovation and Design process. According to LEED, if the building has a mark between 40-49, the building is certified as green. In addition, the building that gets a mark between 50-59 is considered as a green building with a silver certification. Furthermore, the building that collected marks between 60-69 is certified as a golden green building and finally, the building is certified as a platinum green building if that building collected 80 points or higher (Boarin et al., 2014).

Another widely used green building rating system is known as the British Research Establishment Environmental Assessment Method (BREEAM). This rating system was developed in the United Kingdom for assessing buildings based on the effects of these buildings on the environment. To consider any building as green building according to BREEAM, nine criteria should be checked, i.e., management, energy, health and well-being, pollution, transport, land use, ecology, materials and water. The assessment results based on BREEAM are divided into 4 categories: 1-Pass if the building gained 25-39 points. 2- Good if the building collected 40-54 points. 3- Very Good if the building has a mark between 55-69. 4- Excellent if the building was able to collect 70 points or more (Izvekova et al., 2016).

In Palestine, the Palestinian green buildings guidelines were issued in 2013 by the Palestinian Engineers Association with the help of Palestine Higher Green Building Council. The purposes for publishing these guidelines was to reduce the effect of environmental problems that Palestine suffers from, include the limited resources of energy and water and the increasing operational cost of building in Palestine, taking into consideration the environmental, geographic and topographic nature of Palestine.

According to PHGBC (2013), green buildings are defined as the buildings that provide the balance between the environment and the occupants of these buildings, taking into consideration the local environment where these buildings are constructed.

The Palestinian Green Buildings Guidelines mentioned some advantages of green buildings. Such advantages of green buildings include their abilities to save energy, the use of renewable energy sources such as solar and wind energy, the reliance on natural ventilation and daylighting, and finally, reducing the negative effects of buildings on the environment. Furthermore, these buildings could achieve the balance and the integration between human beings and the environment around them through three main elements, which are: the effective use of resources, benefiting from the diverse of the environmental, natural, geographic and social conditions around building area and providing the financial, social and entertainment needs of human lives without affecting on the needs of future generations (PHGBC, 2013).

Based on the Palestinian Green Buildings Guidelines, green buildings in Palestine can be divided into four categories after completing the required assessment process: Bronze category buildings, which are the buildings that score points between 100 and 119 points; Silver category buildings, which are the buildings that score points between 120 and 139 points; Golden category buildings, which are the buildings that score points between 140 and 159 points; and Diamond category buildings, which are the buildings that score 160 points or more.

The total number of attainable assessment points is 200 points, divided amongst six main parts. The first part is site sustainability, which constitutes 15% of the total number of points. The second part is the efficiency in the use of energy, which presents 30% of the total number of points. The third part is the efficiency in the use of water, and forms 25% of the total assessment points. The fourth part is related to the quality of indoor environment, which presents 15% of the total number of points. The fifth part is materials and resources, which forms 10% of the total number of point. Finally, the sixth part is the innovation and the integration included in the design of green buildings, which represents 5% of the assessment points. According to the guidelines, the minimum requirements to assess green buildings in Palestine are:

- The commitment with the local and the international rules which include safety rules.
- The building should be always unable to be moved from its own place.
- The commitment with the appropriate building construction boundaries based on the rules of the local polices.
- The owner of the building should provide full information about energy and water consumption to the PHGBC.
- The building should be used by occupants.
- The building should consume energy and water normally.
- The building should be used for at least 12 months before the assessment of operational and maintenance projects.

2.3 Green Buildings Actual Performance Assessment Methods

One of the most common assessment methods used to assess the actual energy performance of green buildings is comparing their actual consumption of energy with the anticipated consumption.

There are many academic research papers argued that such green buildings often suffer from a gap between their predicted energy consumption level and their actual consumption level, and this gap is known as performance gap (Okland, 2015).

Performance gap has different definitions. According to Ward (2015), performance gap is defined as the difference between the actual performance and the planed performance in design stage. De Wilde (2014) argued that the mismatch between the predicted energy consumption for some simulated buildings and the actual energy consumed for the same buildings is called performance gap. Similarly, Lewry (2015) argued that performance gap is defined as "The difference between anticipated and actual performance". Van Dronkelaar et al. (2016) explained the performance gap as being the difference between the measured energy usage with the compliance and performance simulation modeling.

According to literature, there are many studies support the claim that some buildings suffer from performance gap problem (De Wilde, 2014). For example, a study conducted by Salehi et al. (2015) argued that the results of comparing the actual energy consumption with the predicted consumption of a building in the University of British Columbia, which has a LEED

Platinum certification, showed that its actual energy consumption is higher by around 60% than the designed value for its first year of operation.

Similarly, a study conducted by Diamond et al. (1992) reported that when researchers compared the actual performance of 27 buildings with the predicted values set for those buildings, their findings mentioned that the actual energy consumption of these buildings was 10% and 23% higher than the predicted consumption in the first and the second year respectively.

In another study conducted by Menezes et al. (2012), the results showed that the actual energy usage could reach up to 2.5 times higher than the expected usage.

Bordass et al. (2001) also argued that the actual performance of energy consumption might reach twice higher than the predicted consumption.

According to De Wilde (2014), there are three basic causes that lead to a performance gap, causes that take place during the design stage, causes that take place during the construction stage and finally, causes that take place during the operational stage. Causes related to design stage include miscommunication between the design team, unclear understanding of the future use of the building and problems in modeling (ZCH, 2010; Newsham et al., 2012). Causes related to the construction stage include poor experience of the contractors and the labors, the lack of clarity of some specifications and had therefore left them to the contractor to define and change orders in a method that could lead to performance gap (ZCH, 2010; Menezes et al., 2011). Causes related to the operational stage include the lack of control in consuming energy by the occupants (O´Sullivan et al., 2004).

Similarly, Ward (2015) mentioned eight reasons summarized in the following points:

- Changes to the building design and/or the design intent is not delivered on site.
- Poor quality of construction (such as gaps in insulation and accidental thermal bridging).
- Substitution of building elements and/or services equipment from those originally specified.
- Inadequate or incomplete commissioning.
- Changes in the way that the building is occupied and operated from those assumed during the design of the building.
- Building controls that operators and users find difficult to understand and operate effectively.
- Lack of facilities management, energy monitoring and/or maintenance of building services.
- Behavior of occupants.

In addition, Salehi et al. (2015) explained other reasons for such gap which include the inaccuracy of simulation modeling results, the quality of input data for simulation programs, the residents and their behavior, the actual performance of the mechanical systems, the simplification modeling of complex Heating, Ventilation and Air Conditioning (HVAC) systems and the poor commissioning and building handover.

Another method used to assess the actual energy consumption of green buildings is by comparing their actual consumption with an energy baseline. An energy baseline is defined as a reference tool used to compare the energy consumption of different facilities (John, 2015). Also, energy baseline is identified as the benchmark created to measure and compare energy usage, or energy intensity (WBCSD & WRI, 2004).

According to the definitions above, the main aim of establishing an energy baseline is to measure the energy consumption of different types of facilities. Additional aims of energy baseline include quantifying energy savings of energy efficient buildings, designing buildings to consume energy less than the baseline and helping in improving energy management programs (John, 2015; Fei & Pingfang, 2009).

To create an energy baseline, a sequence of steps should be followed. According to WBCSD & WRI (2004), these steps should start with defining the type of facilities that this baseline is created to compare. The next steps are: defining the number of years that should be included in the energy consumption reports, collecting data from the utility providers and finally, calculating the intensity of the needed energy to be considered as the baseline.

According to a study conducted by the US General Services Administration (GSA), which compared the energy consumption, operating cost and water usage for the 12 GSA buildings with the average baseline of US commercial buildings, the results of that study showed that these 12 buildings consumed less energy than the national average by 26%, 13% lower aggregate maintenance cost, 27% higher occupant satisfaction and 33% fewer CO_2 emissions (Fowler & Rauch, 2008).

According to another case study conducted by Moghimi et al. (2013), which compared the Building Energy Index (BEI) of the University Kebangsaan Malaysia Medical Center (UKMMC) in Malaysia with the BEI of two Malaysian hospitals, in reference to the standard Malaysian BEI and Malaysian Green Building Index (GBI), the results of this study indicate that the BEI of UKMMC hospital is 384 kWh/m²/year, the BEI for the other two hospitals were 217 kWh/m²/year and 297 kWh/m²/year respectively, the standard BEI is 200 kWh/m²/year and the GBI is 120 kWh/m²/year, so UKMMC BEI is three times higher than the recommended GBI and 1.5-2 times higher than the BEI for the 2 other hospitals. It worth to mention that BEI and GBI are as defined an energy intensity used to measure the annual energy consumption of buildings per meter square, BEI is used for traditional buildings while GBI is used for green buildings (Moghimi et al., 2013).

To summarize, this chapter started by discussing the relation between sustainability and green buildings. Then, the chapter provided a summary about the definitions of green buildings and the reasons why the building sector should move towards the construction of more green buildings. Moreover, this chapter provided a summary about building assessment systems and how these systems were developed and provided some examples about different assessment systems used worldwide. Finally, this chapter ended with discussing two of the assessment methods used for assessing the actual performance of green buildings based on their actual energy consumption.

The next chapter will provide the research methodology, research design, sampling methods, population and sampling size.

Chapter Three

Methodology

Chapter Three

Methodology

3.1 Overview

According to Rajasekar et al. (2006), research methodology is defined as the steps followed by researchers throughout their work until solving the research problem.

Every researcher should be able to create his/her own research methodology that is appropriate for his/her research and not only be able to solve mathematical equations. The importance of research methodology is derived from the fact that methodology is a series of systematic steps that need to be followed to answer the research questions, and if the researcher developed a wrong methodology, the researcher will not be able to reach to answers for the research questions (Williams, 2011).

There are many types and methods of research. For example, Rajasekar et al. (2006) discussed three types of research which include a) basic research and applied research, b) normal and revolutionary research, c) quantitative and qualitative research. Basic research is defined as the research which aims to investigate and explain a natural phenomenon and not to provide a solution for practical problem, while applied research is a research that involves solving a specific problem using different applied scientific methods (Rajasekar et al., 2006). Normal research is a research that was performed by following a sequence of steps, rules and procedures, while revolutionary research is a research that applied mostly in natural science to find a novel solution by trials not by a sequence of steps (Rajasekar et al., 2006). Qualitative research is a type of research that is not concerned with numerical values or measurements but concerned with qualitative phenomenon like the quality of the products or the opinion of persons, while quantitative research is related and built up on measurements or quantities of some items (Rajasekar et al., 2006).

Additional research methods include descriptive qualitative method that provides a detailed description situation for a case study using interviews or questionnaires. Also, descriptive quantitative method is a method describes numerical data numerically by calculating the mean and the standard deviation. Correlation analysis method which explains the strength of the relation between two variables or more. Experimental method which aims to conduct an experiment by controlling its variables (Rajasekar et al., 2006).

Based on the definitions provided above, and since the main objective of this study is to create energy consumption baseline using statistical methods, the appropriate research method for this study is a mixed methodology. The first methodology followed in this research is case study methodology because this research will investigate a real case, which is the performance of Aqqaba Green School that is considered as a practical case of green buildings in Palestine. The second methodology followed in this research is a quantitative methodology, to be more specific, this research is considered to be descriptive quantitative research because descriptive statistics will be performed. The definition of descriptive statistics is that part of statistics which is concerned in methods to organize and summarize the collected data (Weiss, 2011).

3.2 Research Design

3.2.1 Overview

As mentioned earlier in chapter one, the main objective of this research is to assess the actual energy consumption levels of a green building in Palestine, which is Aqqaba Green School, by developing an energy and water consumption baselines based on the actual energy and water consumption of non-green schools in Palestine using statistical methods, which represents the developed baseline. The established baseline will be used to compare and assess the actual levels of energy and water consumption of the green school. To create the baseline, the researcher should be able to define the population and sample size of non-green schools in Palestine, the annual energy and water consumption levels of each school in the sample and also, to get the number of students and the built-up areas of schools. Then, the analysis will start by defining and excluding the outliers. The next step will be calculating the descriptive statistics, which include the mean and the standard deviation. After finding the descriptive statistics, the mean of the sample will be considered to be the needed baseline. The following Figure, Figure 3.1 summarizes the research design.

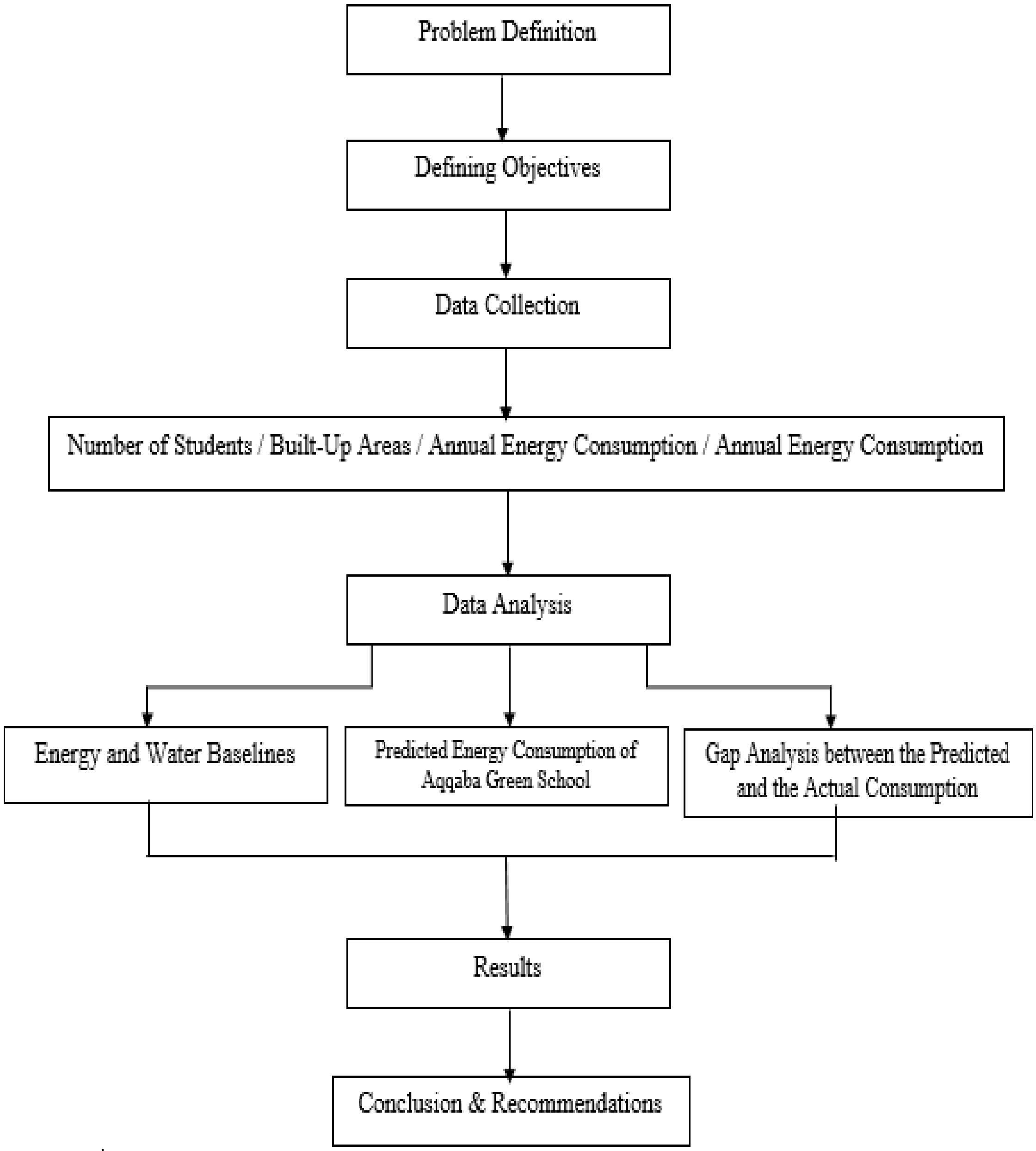

Figure 3.1: Research Methodology

3.2.2 Research Methodology

To establish the needed baseline, the next methodology was followed:

- First, the monthly consumption data for each school was transformed to annual consumption to reduce the variation in the data of the monthly consumption.

- Second, the annual consumption data was ordered in an ascending order.
- Third, the five-number summary analysis (min, Q1, median, Q3, max) was established to calculate the interquartile range (IQR) and Interquartile interval (IQI), so the data outliers of the annual consumption were defined and excluded.
- Fourth, after excluding the outliers of the annual consumption data, the data of built-up areas (for energy consumption analysis) and the data of number of students (for the analysis of water consumption) were ordered from the smallest value to the highest value, then, five number summary analysis was repeated to eliminate the outliers, so the variation in the data of built-up areas and the number of students was reduced.
- Last, the mean, the standard deviation and confidence intervals were calculated using the remained data to establish the baseline, knowing that the mean value of each data was considered as the required baseline which will be used to assess the actual performance of Aqqaba Green School.

3.2.3 Case Study Description

Aqqaba Green School is the first green school in Palestine. The green school is located at Aqqaba Village in the district of Tubas which is hot and dry in the summer and mild in the winter and the average temperature in this region is around 18°C. Aqqaba Green school has been operated since August 2016 and has a built-up area of around 1,408 meter-squared and has 156 students. Furthermore, the green school has 7 classrooms, computer lab, science lab, green areas, three water wells, library, play grounds, gray water recycling system which is used for watering green and play grounds. In addition, Aqqaba Green School has PV system to generate electricity. The green school was certified as a green building with golden certificate by the Palestinian Higher Green Building Council. Figure 3.2 below shows the green areas, ramps, entrances and the plan of the first floor of the Aqqaba Green School (Global Communities, 2018).

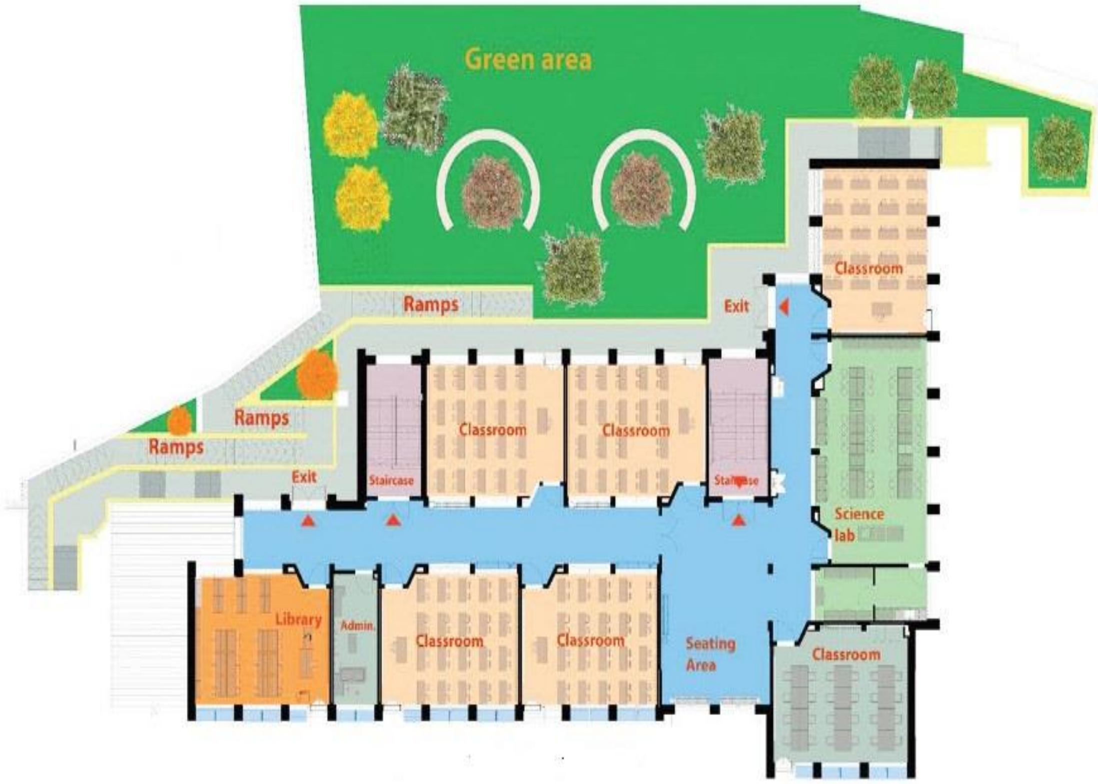

Figure 3.2: The Plan of the First Floor of Aqqaba Green School

3.3 Population, Sampling Methods and Sample Size

3.3.1 Research Population

Since Aqqaba Green School is a governmental school, the population of this study is considered to be all governmental schools in Palestine excluding Gaza Strip. The reason for excluding the schools in Gaza Strip was due to the difficulties in obtaining the required data given their political situation. Therefore, the population of the research is represented by the governmental schools in West Bank.

According to Statistics and Planning Department in the Palestinian Ministry of Education, the number of the governmental schools in West Bank is 1,784 schools divided into 17 governorates as shown in the following Table 3.1 which represents the population size and distribution (Statistics and Planning Department, 2017).

Table 3.1: Schools Distribution by Governorate

Governorate	No. of Schools	Governorate	No. of Schools	Governorate	No. of Schools	Governorate	No. of Schools
Jericho	22	South Hebron	155	Salfit	72	Qabatya	90
Hebron	145	South Nablus	81	North Hebron	104	Qalqilya	81
Jerusalem	49	Jenin	149	Tubas	44	Yatta	79
Bethlehem	131	Ramallah	193	Tulkarm	138	Nablus	176
Jerusalem suburbs	75						

3.3.2 Sampling Methods

According to Weiss (2011), sampling methods are divided into two types. Probability sampling which is defined as the sampling method that is applicable when each element in the population has non-zero probability to be chosen as a part of the sample, and non – probability sampling which is defined as the sampling method that is used when the researcher selects individuals because they are convenient (available to study), or because these elements have special characteristics that the researcher aims to study. In addition, non-probability sampling and probability sampling are implemented using different methods. The non-probability sampling is divided into two types. The first type is called convenient sampling. In this method, researchers select their participants because they are willing and available to participate in the study. The second type is called snowball sampling method. This method is obtained when the researchers ask their participants to convince their relevant persons to become a part of the sample (Creswell, 2010).

The probability sampling method is divided into five main types as follows (Saunders et al., 2009):

1. Simple random sampling: simple random sampling is one of the common sampling methods. The researcher selects each element in the sample randomly using special random selection method which includes random number table, or special computer software to make sure that the probability of choosing any element from the population is equal for all elements.
2. Stratified random sampling: in this method, the population is divided into groups based on specific characteristic called strata, then, random data selection process is performed on each stratum to create a sample

and by doing so, the sample is considered to be well representative by including samples from all stratums.

3. Cluster random sampling: this sampling method is performed by dividing the population into groups based on any grouping methods, then, the clusters are selected randomly, then, the elements of the sample are collected from the selected clusters.
4. Systematic random sampling: using this sampling method, the elements of the sample are collected by choosing each n^{th} element in the population until reaching the needed sample size by calculating sampling fraction by dividing the needed sample size by the population size.
5. Multistage sampling: in this kind of sampling methods, a mix of two or more probability sampling method is used.

According to the constrains of time and cost, the sampling method which was followed in this research was non-probability sampling based on data availability as will be discussed in the next section.

3.3.3 Sample Size

There is no officially published statistical data about energy and water consumption of schools in Palestine, therefore, the standard deviation for energy and water consumption of schools is unknown. Under such conditions, and in order for the results to be statistically significant, and according to the Central Limit Theorem, the sample size should be equal or higher than 30 ($n \geq 30$) regardless of the distribution of the variable under consideration (Box, 1987; Weiss, 2011), so the researcher worked to collect as much data as possible.

Before start collecting the data, the researcher divided and made lists of the Palestinian non-green schools based on districts after collected the list of all schools from Statistics and Planning Department of the Palestinian Ministry of Education. Then, the researcher contacted the main utility service providers of the main Palestinian cities to collect the available consumption reports of the energy and water consumption based on the made lists.

The researcher was able to collect the data related to the monthly energy consumption of 229 schools, and these schools are divided into 98 Secondary schools and 131 elementary schools as summarized in Table 3.2 below.

Table 3.2: Distribution of Schools in the Sample by Region

Region	Elementary Schools	Secondary Schools	Region	Elementary Schools	Secondary Schools
Tulkarm	10	11	North Hebron	10	3
Qalqilia	4	6	South Hebron	14	7
Nablus	11	10	Yatta	10	5
Tubas	3	1	Jericho	4	4
Salfit	6	3	Bethlehem	9	12
Jenin	9	8	Jerusalem	15	4
Hebron	15	11	Ramallah	11	13

Furthermore, the researcher was able to collect the data related to the monthly levels of water consumption for 188 schools of the 229 schools because the researcher was not able to access or visit the utility service providers.

In total, and after contacting and visiting the stations of the main service providers in the main Palestinian cities mentioned in Table 3.2 above, the researcher was able to collect the monthly reports related to energy and water consumption levels for 229 schools and for 188 schools respectively, and these consumption reports were printed on formal papers then submitted to the researcher by hand.

To summarize what was discussed in this chapter, the researcher initiated this chapter by providing the definition of the methodology and the importance of selecting an appropriate methodology for any research, then the researcher discussed the different types of research and summarized the design of this research. Also, this chapter defined the most common sampling methods that is divided into probability sampling and non-probability sampling. Finally, the chapter ended with discussing the population of this research, sample size and the method used to collect the needed data.

The following chapter defines the different types of data needed to answer the questions of this research empirically and how each type of data was used. Also, chapter four provides a description for the steps followed by the researcher in analyzing the collected data.

Chapter Four

Data Collection & Data Analysis

Chapter Four

Data Collection & Data Analysis

4.1 Data Collection

In order to empirically answer the research questions, three types of data were collected. First, a copy of the simulation report containing the value of the expected energy consumption of Aqqaba Green School was collected from the Palestinian Green Building Council. Second, the monthly energy and water consumption reports of the green school and of all schools in the sample were collected from the respective utility service providers. Third, the data related to the areas of schools and the number of students in Aqqaba Green School and of each school in the sample were collected from Statistics and Planning Department in the Palestinian Ministry of Education.

The predicted energy consumption level and the actual energy consumption level of Aqqaba Green School were compared with each other to assess the actual energy consumption of the green school based on the discrepancy between the two values. The monthly energy and water consumption reports were used to calculate the annual consumption of each school, which eliminates the monthly variation in the data. Also, the data related to the annual energy and water consumption was used to develop the required baseline to measure the actual performance of Aqqaba Green School. In addition, the data of built-up areas and number of students were used as parameters to develop baselines based on building energy index per area and per student and based on water use intensity per meter square and per student.

It worth mentioning that Aqqaba Green School is supplied with a photovoltaic (PV) system which has an energy generation capacity of 15 kWp. The researcher has contacted the utility service provider to collect data related to the energy generated by the installed PV system, which is summarized in Table 4.1 below. Based on a meeting conducted with the utility service provider, the utility service provider representative stated that the provided PV system is a grid-connected system connected to the main grid, and the system is being managed as follows: First, the utility service provider supplies the green school with the total energy demand. Second, all energy generated by the PV system is exported to the grid that is operated by the utility service provider. Then, the readings of both energy consumption meter and net energy generation meter are recorded by an officer on behalf of the service provider at the end of each month. And accordingly, clearance is performed each year by subtracting the total energy consumed by the green school from the total net generated energy, and if the clearance shows surplus of energy, the utility services provider credits 75% of the surplus energy to the green school's account at the local electricity tariff, which is around 0.692 ILS/kWh.

Accordingly, to estimate the economic benefits gained from the provided PV system in the first year of operation of Aqqaba Green School, the following equation is applied:

(Total net energy generated – Total billed energy consumption) x 0.75 x 0.692 =

(14,550 kWh/year – 10,124 kWh/year) x 0.75 x 0.692 ILS/kWh = 2,297 ILS.

Table 4.1: Monthly Net Energy exported to the Grid Versus Energy Consumption

Reading Date	Net Energy exported to the Grid (kWh)	Energy Consumption according to electricity bills (kWh)
2/9/2016	3710	1,049
1/10/2016	-220	964
2/11/2016	942	1,121
1/12/2016	435	924
*29/1/2017	1,149	1,679
26/2/2017	1,010	696
28/3/2017	1,062	700
27/4/2017	1,524	750
29/5/2017	1,511	872
1/7/2017	1,188	573
31/7/2017	2,239	796
Total	14,550	10,124

*This reading covers two months, December 2016 and January 2017.

4.2 Data Analysis

4.2.1 Performance Measurements of Aqqaba Green School in Comparison to other Schools in Different Categories

Energy baseline is a reference tool used to assess and compare the energy consumed within a certain facility. In this research, energy baseline was developed to assess the actual energy consumption of Aqqaba Green School and to quantify the amount of savings in energy and water consumption and cost.

Based on the above approach, and in order to create the needed baseline, data analysis was divided into several stages as follows:

Stage 1: The collected data related to the energy and water consumption were tabulated to calculate the annual consumption and the annual cost of each school as shown in Table 4.2. As mentioned in the previous section, the monthly data was converted to annual consumption to avoid variations in the monthly consumption.

Stage 2: The data of vocational secondary schools (schools that teach students special crafts like sewing, carpentry, and blacksmithing) was excluded since the nature of these schools is different than the traditional schools, and therefore, the energy and water use patterns are significantly different from other schools due to the used equipment and tools.

Stage 3: The data related to the annual energy and water consumption was divided into two spread sheets; one for secondary schools and another for elementary schools, as shown in Table 4.2 below, knowing that the data of elementary schools starts from school number 95, while the rest of the data is considered as the data of secondary schools. Table 4.2 contains data related to school number, annual energy and water consumption, annual consumption cost, school areas and the number of students in each school.

Table 4.2: Summary of the Annual Energy and Water Consumption of Secondary and Elementary Schools

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square (kWh/m^2/year)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square (m^3/m^2/year)	Water Use Intensity Per Student (m^3/Student/year)
1	13,034	9,256	1,072	3,928	1,890	296	6.90	44.03	0.57	3.62
2	6,375	3,650	1,192	4,513	659	226	9.67	28.21	1.81	5.27
3	12,449	8,873	608	2,145	1,600	545	7.78	22.84	0.38	1.12
4	11,900	8,494	545	1,900	1,800	504	6.61	23.61	0.30	1.08
5	10,526	7,546	468	1,562	1,800	340	5.85	30.96	0.26	1.38
6	8,012	5,811	920	3,358	1,800	342	4.45	23.43	0.51	2.69
7	10,247	7,354	1,002	3,690	2,400	318	4.27	32.22	0.42	3.15
8	12,920	9,198	1,313	4,892	2,200	365	5.87	35.40	0.60	3.60
9	15,273	10,822	2,452	15,578	2,500	629	6.11	24.28	0.98	3.90
10	15,578	11,033	731	2,587	2,100	602	7.42	25.88	0.35	1.21
11	8,049	5,837	419	1,409	1,676	424	4.80	18.98	0.25	0.99
12	8,923	5,478	322	2,336	2,064	411	4.32	21.71	0.16	0.78
13	14,104	8,648	Not available	Not available	1,872	385	7.53	36.63	-	-
14	8,723	5,348	662	6,066	1,140	437	7.65	19.96	0.58	1.51

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
15	14,014	8,598	343	2,446	2,546	625	5.50	22.42	0.13	0.55
16	11,017	6,761	388	3,056	3,025	554	3.64	19.89	-	-
17	10,578	6,493	Not available	Not available	1,970	357	5.37	29.63	0.01	0.06
18	16,704	10,244	320	2,271	2,403	486	6.95	34.37	0.13	0.66
19	37,125	22,767	552	4,743	4,400	505	8.44	73.51	0.13	1.09
20	8,253	5,064	165	1,161	1,260	393	6.55	21.00	0.13	0.42
21	10,703	6,562	341	2,726	1,200	160	8.92	66.89	0.28	2.13
22	10,156	7,018	1,130	10,216	2,470	442	4.11	22.98	0.46	2.56
23	18,357	12,666	735	3,165	1,170	163	15.69	112.62	0.63	4.51
24	4,900	3,381	270	1,000	1,765	340	2.78	14.41	0.15	0.79
25	9,220	5,660	104	547	780	260	11.82	35.46	0.13	0.40
26	14,265	8,751	Not available	Not available	1,003	342	14.22	14.22	-	-
27	15,978	9,816	992	5,380	6,000	546	2.66	29.26	0.17	1.82
28	7,713	4,733	245	1,231	1,600	234	4.82	12.86	0.15	1.05
29	12,768	7,840	213	1,069	1,698	380	7.52	33.60	0.13	0.56
30	12,862	7,894	317	1,639	1,272	238	10.11	54.04	0.25	1.33
31	13,616	8,360	295	1,419	2,100	509	6.48	26.75	0.14	0.58

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
32	11,095	8,507	799	6,091	3,323	330	3.34	24.96	0.24	2.42
33	15,854	11,499	325	2,040	2,547	555	6.22	7.52	0.13	0.59
34	17,084	9,415	387	2,412	10,723	498	1.59	9.59	0.04	0.78
35	1,231	20,253	214	1,194	1,890	485	0.65	12.75	0.11	0.44
36	31,246	27,701	1,540	12,750	2,415	604	12.96	43.97	0.64	2.55
37	13,183	9,618	748	5,683	1,743	497	7.56	53.46	0.43	1.51
38	3,946	3,161	234	1,376	386	240	10.22	16.44	0.61	0.98
39	9,138	6,691	389	2,659	2,637	448	3.47	20.40	0.15	0.87
40	26,559	19,052	335	2,024	2,500	411	10.62	64.62	0.13	0.82
41	26,568	18,844	691	5,163	4,885	292	5.44	90.99	0.14	2.37
42	4,249	3,367	484	3,706	2,000	290	2.12	14.65	0.24	1.67
43	29,520	21,378	365	2,315	800	523	37.49	57.34	0.46	0.70
44	20,519	14,703	689	5,111	2,885	266	7.11	77.14	0.24	2.59
45	10,191	7,162	1,248	2,174	2,430	545	4.19	18.70	0.51	2.29
46	7,207	5,065	327	496	1,547	292	4.66	24.68	0.21	1.12
47	16,173	11,367	683	1,004	1,450	366	11.15	44.19	0.47	1.87
48	12,919	9,080	1,162	1,993	1,500	453	8.61	28.52	0.77	2.57

School Number	**Annual Electricity Consumption (kWh)**	**Annual Energy Cost (ILS)**	**Annual Water Consumption (m^3)**	**Annual Water Cost (ILS)**	**Built-up Area (m^2)**	**No. of Students**	**Building Energy Index per Meter Square (kWh/m^2/year)**	**Building Energy Index per student (kWh/Student/year)**	**Water Use Intensity per Meter Square (m^3/m^2/year)**	**Water Use Intensity Per Student (m^3/Student/year)**
49	17,607	12,374	1,174	2,549	2,335	446	7.54	39.48	0.50	2.63
50	20,400	14,337	2,927	6,808	1,800	358	11.33	56.98	1.63	8.18
51	39,348	27,511	248	1,157	1,548	847	25.42	46.46	0.16	0.29
52	18,505	13,106	207	2,053	1,850	538	10.00	34.40	0.11	0.38
53	13,378	9,596	251	1,373	2,800	465	4.78	28.77	0.09	0.54
54	23,094	16,281	358	1,865	4,500	840	5.13	27.49	0.08	0.43
55	14,123	24,251	202	1,040	1,500	478	9.42	29.55	0.13	0.42
56	9,783	7,419	152	858	1,188	427	8.23	22.91	0.13	0.36
57	13,158	9,196	115	1,268	1,297	483	10.14	27.24	0.09	0.24
58	9,712	6,917	247	1,218	1,950	570	4.98	17.04	0.13	0.43
59	4,044	3,115	Not available	Not available	2,663	766	1.52	5.28	-	-
60	18,303	12,959	1,024	5,028	1,350	684	13.56	26.76	0.76	1.50
61	8,321	6,034	Not available	Not available	1,707	527	4.87	15.79	-	-
62	6,712	4,923	151	604	2,391	530	2.81	12.66	0.06	0.28
63	5,293	4,002	0	0	1,272	416	4.16	12.72	0.00	0.00
64	10,597	7,608	262	1,048	1,315	430	8.06	24.64	0.20	0.61
65	7,271	5,310	105	420	1,192	412	6.10	17.65	0.09	0.25

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
66	26,191	18,847	2,754	19,636	1,360	465	19.26	56.32	2.03	5.92
67	19,283	15,092	590	1,513	2,940	292	6.56	66.04	0.20	2.02
68	25,230	19,241	1,390	6,640	2,000	552	12.62	45.71	0.70	2.52
69	35,788	25,934	731	1,369	1,200	199	29.82	179.84	0.61	3.67
70	6,314	4,686	391	1,991	500	545	12.63	11.59	0.78	0.72
71	8,871	6,449	330	1,686	2,800	433	3.17	20.49	0.12	0.76
72	8,164	5,956	192	996	2,000	385	4.08	21.21	0.10	0.50
73	8,743	6,374	Not available	Not available	350	163	24.98	53.64	-	-
74	10,882	7,854	379	3,262	923	300	11.79	36.27	0.41	1.26
75	13,447	9,626	152	994	1,842	421	7.30	31.94	0.08	0.36
76	12,793	9,162	Not available	Not available	390	481	32.80	26.60	-	-
77	9,030	6,572	150	918	100	366	90.30	24.67	1.50	0.41
78	9,950	7,208	440	2,767	2,100	320	4.74	31.09	0.21	1.38
79	3,134	2,573	432	3,183	3,400	292	0.92	10.73	0.13	1.48
80	8,213	6,185	322	2,342	908	259	9.05	31.71	0.35	1.24
81	11,825	8,709	732	4,662	1,602	410	7.38	28.84	0.46	1.79
82	6,417	4,856	263	1,419	850	210	7.55	30.56	0.31	1.25

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square (kWh/m^2/year)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square (m^3/m^2/year)	Water Use Intensity Per Student (m^3/Student/year)
83	22,198	15,923	1,595	14,467	1,800	585	12.33	37.95	0.89	2.73
84	10,208	7,512	197	1,062	1,370	413	7.45	24.72	0.14	0.48
85	13,322	9,759	792	6,591	2,788	565	4.78	23.58	0.28	1.40
86	16,643	12,011	Not available	Not available	1,920	505	8.67	32.96	-	-
87	22,603	16,196	371	3,072	1,914	700	11.81	32.29	0.19	0.53
88	14,115	10,412	185	1,273	2,440	429	5.78	32.90	0.08	0.43
89	17,121	12,404	121	687	932	421	18.37	40.67	0.13	0.29
90	16,192	11,930	133	884	1,200	432	13.49	37.48	0.11	0.31
91	4,895	4,454	Not Available	Not Available	560	101	8.74	48.47	-	-
92	48,293	31,376	Not Available	Not Available	1,345	666	35.91	72.51	-	-
93	16,798	11,645	Not Available	Not Available	263	107	63.87	156.99	-	-
94	14,037	10,882	Not Available	Not Available	5,458	441	2.57	31.83	-	-
(ES) 95	6,515	4,579	679	960	1,750	649	3.72	10.04	0.39	1.05
96	8,191	5,757	294	460	1,350	355	6.07	23.07	0.22	0.83

(ES): The start of the data of elementary schools

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
97	17,729	12,460	1,817	4,082	3,192	652	5.55	27.19	0.57	2.79
98	16,323	11,472	1,558	3,279	1,240	450	13.16	36.27	1.26	3.46
99	7,345	5,352	500	1,688	800	377	9.18	19.48	0.63	1.33
100	11,299	8,080	1,367	5,108	2,628	535	4.30	21.12	0.52	2.56
101	5,964	4,399	327	1,139	1,536	341	3.88	17.49	0.21	0.96
102	10,270	7,370	1,574	6,026	733	274	14.01	37.48	2.15	5.74
103	10,746	7,699	981	3,568	900	253	11.94	42.47	1.09	3.88
104	7,294	5,292	393	1,295	1,500	366	4.86	19.93	0.26	1.07
105	1,058	7,555	704	2,550	3,300	616	0.32	1.72	0.21	1.14
106	10,864	7,780	1,374	5,173	1,300	504	8.36	21.56	1.06	2.73
107	7,633	5,550	1,051	3,982	1,410	358	5.41	21.32	0.75	2.94
108	10,648	7,630	870	3,143	1,100	395	9.68	26.96	0.79	2.20
109	13,886	8,516	458	3,663	1,830	417	7.59	33.30	0.25	1.10
110	4,402	2,700	Not available	Not available	1,000	66	4.40	66.70	-	-
111	9,141	5,608	289	1,935	690	444	13.25	20.59	0.42	0.65
112	4,464	3,736	Not available	Not available	330	83	13.53	53.78	-	-
113	6,411	3,934	350	2,597	950	291	6.75	22.03	0.37	1.20

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
114	4,480	2,747	141	779	388	156	11.55	28.72	0.36	0.90
115	4,633	2,842	132	795	640	171	7.24	27.09	0.21	0.77
116	6,214	3,810	315	2,435	1,400	426	4.44	14.59	0.23	0.74
117	1,760	1,080	158	862	273	183	6.45	9.62	0.58	0.86
118	10,095	6,194	164	897	450	237	22.43	42.59	0.36	0.69
119	5,806	3,561	192	1,103	908	267	6.39	21.75	0.21	0.72
120	6,680	4,616	339	2,129	2,001	483	3.34	13.83	0.17	0.70
121	8,534	5,920	250	1,463	4,000	597	2.13	14.29	0.06	0.42
122	15,995	11,052	485	2,895	2,280	758	7.02	21.10	0.21	0.64
123	9,827	6,781	962	4,268	1,160	445	8.47	22.08	0.83	2.16
124	8,595	5,931	329	1,256	1,360	366	6.32	23.48	0.24	0.90
125	6,870	4,740	344	1,337	880	264	7.81	26.02	0.39	1.30
126	14,542	10,034	602	2,529	1,716	344	8.47	42.27	0.35	1.75
127	9,133	6,302	551	2,366	2,046	315	4.46	28.99	0.27	1.75
128	1,765	1,218	107	379	320	39	5.52	45.26	0.33	2.74
129	7,134	4,382	598	2,992	1,578	364	4.52	19.60	0.38	1.64
130	5,007	3,072	Not available	Not available	1,720	357	2.91	14.03	-	-

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
131	13,226	8,118	260	1,258	3,900	446	3.39	29.65	0.07	0.58
132	9,689	5,945	148	794	2,250	412	4.31	23.52	0.07	0.36
133	15,495	9,512	472	2,300	1,050	451	14.76	34.36	0.45	1.05
134	7,679	4,711	108	574	9,115	317	0.84	24.22	0.01	0.34
135	9,116	5,599	245	1,223	2,250	458	4.05	19.90	0.11	0.53
136	19,596	12,029	1,249	6,802	1,500	360	13.06	54.43	0.83	3.47
137	13,494	8,282	108	614	1,650	603	8.18	22.38	0.07	0.18
138	15,280	11,079	544	3,795	2,000	405	7.64	37.73	0.27	1.34
139	12,912	9,363	663	4,999	1,717	306	7.52	42.20	0.39	2.17
140	25,629	19,135	442	2,939	1,836	434	13.96	59.05	0.24	1.02
141	13,590	9,713	358	2,216	2,634	389	5.16	34.94	0.14	0.92
142	12,453	9,048	528	3,832	1,000	371	12.45	33.57	0.53	1.42
143	20,224	14,534	2,038	17,263	1,544	393	13.10	51.46	1.32	5.19
144	15,850	11,491	642	5,683	2,040	365	7.77	43.42	0.31	1.76
145	9,237	6,771	578	4,258	640	229	14.43	40.34	0.90	2.52
146	4,174	4,669	266	1,666	900	272	4.64	15.35	0.30	0.98

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
147	4,778	4,067	216	1,267	1,114	205	4.29	23.31	0.19	1.05
148	6,186	4,067	184	1,023	933	133	6.63	46.51	0.20	1.38
149	3,864	3,051	100	550	1,524	653	2.54	5.92	0.07	0.15
150	16,750	11,884	Not available	Not available	2,100	550	7.98	30.45	-	-
151	15,001	10,685	467	2,237	1,650	563	9.09	26.64	0.28	0.83
152	14,948	10,375	784	3,970	1,789	414	8.36	36.11	0.44	1.89
153	7,119	5,241	484	2,443	2,340	751	3.04	9.48	0.21	0.64
154	14,688	10,468	496	2,446	2,864	645	5.13	22.77	0.17	0.77
155	7,132	5,246	296	1,599	950	391	7.51	18.24	0.31	0.76
156	12,434	8,901	379	2,010	3,410	390	3.65	31.88	0.11	0.97
157	15,570	11,090	203	923	1,500	589	10.38	26.43	0.14	0.34
158	14,222	10,151	1,072	5,324	2,100	690	6.77	20.61	0.51	1.55
159	4,961	3,756	326	1,658	1,000	348	4.96	14.26	0.33	0.94
160	22,839	16,118	643	3,096	2,400	669	9.52	34.14	0.27	0.96
161	29,966	21,025	Not available	Not available	3,000	282	9.99	106.26	-	-
162	8,983	7,234	170	931	1,500	520	5.99	17.28	0.11	0.33

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square (kWh/m^2/year)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square (m^3/m^2/year)	Water Use Intensity Per Student (m^3/Student/year)
163	19,202	13,597	311	1,595	1,100	558	17.46	34.41	0.28	0.56
164	7,229	5,279	217	868	700	480	10.33	15.06	0.31	0.45
165	4,832	3,623	296	1,184	738	328	6.55	14.73	0.40	0.90
166	8,364	6,064	140	560	1,180	358	7.09	23.36	0.12	0.39
167	7,739	5,647	0	0	820	614	9.44	12.60	0.00	0.00
168	5,864	4,357	Not available	Not available	1,500	487	3.91	12.04	-	-
169	11,216	11,596	338	1,352	1,280	426	8.76	26.33	0.26	0.79
170	17,057	12,071	Not available	Not available	540	484	31.59	35.24	-	-
171	10,300	7,403	Not available	Not available	2,000	573	5.15	17.98	-	-
172	8,475	6,141	194	776	2,100	546	4.04	15.52	0.09	0.36
173	6,671	4,905	229	916	1,600	625	4.17	10.67	0.14	0.37
174	24,073	17,289	1,879	10,750	4,400	628	5.47	38.33	0.43	2.99
175	18,172	13,200	1,034	2,852	1,305	324	13.92	56.09	0.79	3.19
176	4,797	3,698	407	567	1,425	127	3.37	37.77	0.29	3.20
177	34,500	24,677	2,324	15,650	2,250	538	15.33	64.13	1.03	4.32
178	9,789	7,096	256	1,565	1,552	446	6.31	21.95	0.16	0.57

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
179	577	677	186	1,128	484	232	1.19	2.49	0.38	0.80
180	3,056	2,444	280	2,153	1,863	548	1.64	5.58	0.15	0.51
181	6,299	4,686	276	2,342	1,420	445	4.44	14.16	0.19	0.62
182	13,030	9,335	504	3,657	1,800	753	7.24	17.30	0.28	0.67
183	3,746	2,921	Not available	Not available	840	207	4.46	18.10	-	-
184	4,342	3,334	Not available	Not available	1,500	335	2.89	12.96	-	-
185	1,534	1,393	Not available	Not available	500	113	3.07	13.58	-	-
186	1,249	1,188	Not available	Not available	500	54	2.50	23.13	-	-
187	1,741	1,532	109	780	242	124	7.19	14.04	0.45	0.88
188	13,239	9,481	284	2,132	930	693	14.24	19.10	0.31	0.41
189	8,200	5,947	277	2,094	1,439	532	5.70	15.41	0.19	0.52
190	2,529	2,081	345	2,283	505	251	5.01	10.08	0.68	1.37
191	11,612	8,356	433	3,166	1,190	638	9.76	18.20	0.36	0.68
192	18,113	12,841	397	2,021	850	606	21.31	29.89	0.47	0.66
193	5,734	4,284	388	1,976	1,220	320	4.70	17.92	0.32	1.21
194	7,445	5,463	332	1,696	460	234	16.18	31.82	0.72	1.42
195	8,671	6,308	408	2,076	960	677	9.03	12.81	0.43	0.60

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
196	10,432	7,530	477	2,271	2,012	523	5.18	19.95	0.24	0.91
197	3,651	2,847	383	1,951	2,360	217	1.55	16.82	0.16	1.76
198	2,821	2,267	441	2,241	582	169	4.85	16.69	0.76	2.61
199	12,388	8,873	322	1,646	6,000	554	2.06	22.36	0.05	0.58
200	6,368	4,715	310	1,586	1,108	310	5.75	20.54	0.28	1.00
201	6,480	4,800	423	2,151	1,590	195	4.08	33.23	0.27	2.17
202	10,572	7,793	439	3,592	1,200	356	8.81	29.70	0.37	1.23
203	4,885	3,782	540	4,227	1,830	351	2.67	13.92	0.30	1.54
204	4,292	3,352	696	4,489	1,000	328	4.29	13.09	0.70	2.12
205	19,326	13,989	329	2,402	2,574	855	7.51	22.60	0.13	0.38
206	8,120	5,994	405	3,119	2,100	319	3.87	25.45	0.19	1.27
207	9,393	6,964	574	4,943	1,280	519	7.34	18.10	0.45	1.11
208	8,292	5,156	1,745	14,052	2,500	356	3.32	23.29	0.70	4.90
209	10,667	7,835	1,114	9,897	1,200	326	8.89	32.72	0.93	3.42
210	17,527	13,171	330	2,701	3,912	374	4.48	46.86	0.08	0.88
211	12,708	9,053	Not available	Not available	319	81	39.84	156.89	-	-
212	15,857	11,080	Not Available	Not Available	225	91	70.48	174.25	-	-

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square (kWh/m^2/year)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square (m^3/m^2/year)	Water Use Intensity Per Student (m^3/Student/year)
213	8,705	5,654	Not Available	Not Available	413	214	21.08	40.68	-	-
214	40,061	51,958	Not Available	Not Available	557	145	71.92	276.28	-	-
215	8,295	6,226	Not Available	Not Available	231	82	35.91	101.16	-	-
216	10,390	5,409	Not Available	Not Available	1,122	307	9.26	33.84	-	-
217	2,789	2,707	Not Available	Not Available	806	154	3.46	18.11	-	-
218	4,160	3,784	Not Available	Not Available	580	275	7.17	15.13	-	-
219	24,602	17,947	Not Available	Not Available	587	301	41.91	81.73	-	-
220	26,542	19,963	Not Available	Not Available	1,812	383	14.65	69.30	-	-
221	8,618	7,622	Not Available	Not Available	1,148	195	7.51	44.19	--	-
222	9,849	7,213	Not Available	Not Available	955	432	10.31	22.80	-	-
223	20,728	14,296	Not Available	Not Available	486	96	42.65	215.92	-	-
224	3,072	2,892	Not Available	Not Available	105	60	29.26	51.20	-	-
225	10,241	7,522	Not Available	Not Available	721	358	14.20	28.61	-	-

Table 4.3: The Data of Annual Energy Consumption Ordered Ascendingly

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
1	577	677	186	1,128	484	232	1.19	2.49	0.38	0.80
2	1,058	7,555	704	2,550	3,300	616	0.32	1.72	0.21	1.14
3	1,231	20,253	214	1,194	1,890	485	0.65	12.75	0.11	0.44
4	1,249	1,188	Not available	Not available	500	54	2.50	23.13	-	-
5	1,534	1,393	Not available	Not available	500	113	3.07	13.58	-	-
6	1,741	1,532	109	780	242	124	7.19	14.04	0.45	0.88
7	1,760	1,080	158	862	273	183	6.45	9.62	0.58	0.86
8	1,765	1,218	107	379	320	39	5.52	45.26	0.33	2.74
9	2,529	2,081	345	2,283	505	251	5.01	10.08	0.68	1.37
10	2,789	2,707	Not available	Not available	806	154	3.46	18.11	-	-
11	2,821	2,267	441	2,241	582	169	4.85	16.69	0.76	2.61

* Outlier value was excluded based on the analysis of annual energy consumption

** Outlier value was excluded based on the analysis of annual water consumption

***Outlier value was excluded based on the analysis of annual energy and water consumption

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
12	3,056	2,444	280	2,153	1,863	548	1.64	5.58	0.15	0.51
13	3,072	2,892	Not available	Not available	105	60	29.26	51.20	-	-
14	3,134	2,573	432	3,183	3,400	292	0.92	10.73	0.13	1.48
15	3,651	2,847	383	1,951	2,360	217	1.55	16.82	0.16	1.76
16	3,746	2,921	Not available	Not available	840	207	4.46	18.10	-	-
17	3,864	3,051	100	550	1,524	653	2.54	5.92	0.07	0.15
18	3,946	3,161	234	1,376	386	240	10. 22	16.44	0.61	0.98
19	4,044	3,115	Not available	Not available	2,663	766	1.52	5.28	-	-
20	4,160	3,784	Not available	Not available	580	275	7.17	15.13	-	-
21	4,174	4,669	266	1,666	900	272	4.64	15.35	0.30	0.98
22	4,249	3,367	484	3,706	2,000	290	2.12	14.65	0.24	1.67
23	4,292	3,352	696	4,489	1,000	328	4.29	13.09	0.70	2.12
24	4,342	3,334	Not available	Not available	1,500	335	2.89	12.96	-	-
25	4,402	2,700	Not available	Not available	1,000	66	4.40	66.70	-	-
26	4,464	3,736	Not available	Not available	330	83	13.53	53.78	-	-
27	4,480	2,747	141	779	388	156	11.55	28.72	0.36	0.90
28	4,633	2,843	132	795	640	171	7.24	27.09	0.21	0.77
29	4,778	4,067	216	1,267	1,114	205	4.29	23.31	0.19	1.05
30	4,797	3,698	407	567	1,425	127	3.37	37.77	0.29	3.20

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
31	4,832	3,623	296	1,184	738	328	6.55	14.73	0.40	0.90
32	4,885	3,782	540	4,227	1,830	351	2.67	13.92	0.30	1.54
33	4,895	4,454	Not available	Not available	560	101	8.74	48.47	-	-
34	4,900	3,381	270	1,000	1,765	340	2.78	14.41	0.15	0.79
35	4,961	3,756	326	1,658	1,000	348	4.96	14.26	0.33	0.94
36	5,007	3,072	Not available	Not available	1,720	357	2.91	14.03	-	-
37	5,293	4,002	Not available	Not available	1,272	416	4.16	12.72	-	-
38	5,734	4,284	388	1,976	1,220	320	4.70	17.92	0.32	1.21
39	5,806	3,561	192	1,103	908	267	6.39	21.75	0.21	0.72
40	5,864	4,357	Not available	Not available	1500	487	3.91	12.04	-	-
41	5,964	4,399	327	1,139	1,536	341	3.88	17.49	0.21	0.96
42	6,186	4,067	184	1,023	933	133	6.63	46.51	0.20	1.38
43	6,214	3,810	315	2,435	1,400	426	4.44	14.59	0.23	0.74
44	6,299	4,686	276	2,342	1,420	445	4.44	14.16	0.19	0.62

* Outlier value was excluded based on the analysis of annual energy consumption

** Outlier value was excluded based on the analysis of annual water consumption

***Outlier value was excluded based on the analysis of annual energy and water consumption

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
45	6,314	4,686	391	1,991	500	545	12.63	11.59	0.78	0.72
46	6,368	4,715	310	1,586	1,108	310	5.75	20.54	0.28	1.00
47	6,375	3,650	1,192	4,513	659	226	9.67	28.21	1.81	5.27
48	6,411	3,934	350	2,597	950	291	6.75	22.03	0.37	1.20
49	6,417	4,856	263	1,419	850	210	7.55	30.56	0.31	1.25
50	6,480	4,800	423	2,151	1,590	195	4.08	33.23	0.27	2.17
51	6,515	4,579	679	960	1,750	649	3.72	10.04	0.39	1.05
52	6,671	4,905	229	916	1,600	625	4.17	10.67	0.14	0.37
53	6,680	4,616	339	2,129	2,001	483	3.34	13.83	0.17	0.70
54	6,712	4,923	151	604	2,391	530	2.81	12.66	0.06	0.28
55	6,870	4,740	344	1,337	880	264	7.81	26.02	0.39	1.30
56	7,119	5,241	484	2,443	2,340	751	3.04	9.48	0.21	0.64
57	7,132	5,246	296	1,599	950	391	7.51	18.24	0.31	0.76
58	7,134	4,382	598	2,992	1,578	364	4.52	19.60	0.38	1.64
59	7,207	5,065	327	496	1,547	292	4.66	24.68	0.21	1.12
60	7,229	5,279	217	868	700	480	10.33	15.06	0.31	0.45
61	7,271	5,310	105	420	1,192	412	6.10	17.65	0.09	0.25
62	7,294	5,292	393	1,295	1,500	366	4.86	19.93	0.26	1.07

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
63	7,345	5,352	500	1,688	800	377	9.18	19.48	0.63	1.33
64	7,445	5,463	332	1,696	460	234	16.18	31.82	0.72	1.42
65	7,633	5,550	1,051	3,982	1,410	358	5.41	21.32	0.75	2.94
66	*7,679	*4,711	108	574	*9,115	*317	*0.84	*24.22	0.01	0.34
67	7,713	4,733	245	1,231	1,600	234	4.82	12.86	0.15	1.05
68	7,739	5,647	Not available	Not available	820	614	9.44	12.60	-	-
69	8,012	5,812	920	3,358	1,800	342	4.45	23.43	0.51	2.69
70	8,049	5,837	419	1,409	1,676	424	4.80	18.98	0.25	0.99
71	8,120	5,994	405	3,119	2,100	319	3.87	25.45	0.19	1.27
72	8,164	5,956	192	996	2,000	385	4.08	21.21	0.10	0.50
73	8,191	5,757	294	461	1,350	355	6.07	23.07	0.22	0.83
74	8,200	5,947	277	2,094	1,439	532	5.70	15.41	0.19	0.52

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School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square (kWh/m^2/year)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square (m^3/m^2/year)	Water Use Intensity Per Student (m^3/Student/year)
75	8,213	6,185	322	2,342	908	259	9.05	31.71	0.35	1.24
76	8,253	5,064	165	1,161	1,260	393	6.55	21.00	0.13	0.42
77	8,292	5,156	**1,745	**14,052	**2,500	**356	3.32	23.29	**0.70	**4.90
78	8,295	6,226	Not available	Not available	231	82	35.91	101.16	-	-
79	8,321	6,034	Not available	Not available	1,707	527	4.87	15.79	-	-
80	8,364	6,064	140	560	1,180	358	7.09	23.36	0.12	0.39
81	8,475	6,141	194	776	2,100	546	4.04	15.52	0.09	0.36
82	*8,534	*5,920	250	1,463	*4,000	*597	*2.13	*14.29	0.06	0.42
83	8,595	5,931	329	1,256	1,360	366	6.32	23.48	0.24	0.90
84	8,618	7,622	Not available	Not available	1,148	195	7.51	44.19	-	-
85	8,671	6,308	408	2,076	960	677	9.03	12.81	0.43	0.60
86	8,705	5,654	Not available	Not available	413	214	21.08	40.68	-	-
87	8,723	5,348	662	6,066	1,140	437	7.65	19.96	0.58	1.51

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School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
88	8,743	6,374	Not available	Not available	350	163	24.98	53.64	-	-
89	8,871	6,449	330	1,686	2,800	433	3.17	20.49	0.12	0.76
90	8,923	5,478	322	2,336	2,064	411	4.32	21.71	0.16	0.78
91	8,983	7,234	170	931	1,500	520	5.99	17.28	0.11	0.33
92	9,030	6,572	150	918	100	366	90.30	24.67	1.50	0.41
93	9,116	5,599	245	1,223	2,250	458	4.05	19.90	0.11	0.53
94	9,133	6,302	551	2,366	2,046	315	4.46	28.99	0.27	1.75
95	9,138	6,691	389	2,659	2,637	448	3.47	20.40	0.15	0.87
96	9,141	5,609	289	1,935	690	444	13.25	20.59	0.42	0.65
97	9,220	5,660	104	547	780	260	11.82	35.46	0.13	0.40
98	9,237	6,771	578	4,258	640	229	14.43	40.34	0.90	2.52
99	9,393	6,964	574	4,943	1,280	519	7.34	18.10	0.45	1.11
100	9,689	5,945	148	794	2,250	412	4.31	23.52	0.07	0.36

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School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square (kWh/m^2/year)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square (m^3/m^2/year)	Water Use Intensity Per Student (m^3/Student/year)
101	9,712	6,917	247	1,218	1,950	570	4.98	17.04	0.13	0.43
102	9,783	7,419	152	858	1,188	427	8.23	22.91	0.13	0.36
103	9,789	7,096	256	1,565	1,552	446	6.31	21.95	0.16	0.57
104	9,827	6,781	962	4,268	1,160	445	8.47	22.08	0.83	2.16
105	9,849	7,213	Not available	Not available	955	432	10.31	22.80	-	-
106	9,950	7,208	440	2,767	2,100	320	4.74	31.09	0.21	1.38
107	10,095	6,194	164	897	450	237	22.43	42.59	0.36	0.69
108	10,156	7,018	1,130	10,216	2,470	442	4.11	22.98	0.46	2.56
109	10,191	7,162	1,248	2,174	2,430	545	4.19	18.70	0.51	2.29
110	10,208	7,512	197	1,062	1,370	413	7.45	24.72	0.14	0.48
111	10,241	7,522	Not available	Not available	721	358	14.20	28.61	-	-
112	10,247	7,354	1,002	3,690	2,400	318	4.27	32.22	0.42	3.15
113	10,270	7,370	**1,574	**6,026	**733	**274	14.01	37.48	**2.15	**5.74
114	10,300	7,403	Not available	Not available	2,000	573	5.15	17.98	-	-

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School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
115	10,390	5,409	Not available	Not available	1,122	307	9.26	33.84	-	-
116	10,432	7,530	477	2,271	2,012	523	5.18	19.95	0.24	0.91
117	10,526	7,547	468	1,562	1,800	340	5.85	30.96	0.26	1.38
118	10,572	7,793	439	3,592	1,200	356	8.81	29.70	0.37	1.23
119	10,578	6,493	Not available	Not available	1,970	357	5.37	29.63	-	-
120	10,597	7,608	262	1,048	1,315	430	8.06	24.64	0.20	0.61
121	10,648	7,631	870	3,143	1,100	395	9.68	26.96	0.79	2.20
122	10,667	7,835	1,114	9,897	1,200	326	8.89	32.72	0.93	3.42
123	10,703	6,562	341	2,726	1,200	160	8.92	66.89	0.28	2.13
124	10,746	7,699	981	3,568	900	253	11.94	42.47	1.09	3.88
125	10,864	7,780	**1,374	**5,173	**1,300	**504	8.36	21.56	**1.06	**2.73
126	10,882	7,854	379	3,262	923	300	11.79	36.27	0.41	1.26
127	11,017	6,761	388	3,056	3,025	554	3.64	19.89	0.13	0.70
128	11,095	8,507	799	6,091	3,323	330	3.34	24.96	0.24	2.42
129	11,216	11,596	338	1,352	1,280	426	8.76	26.33	0.26	0.79
130	11,299	8,080	1,367	5,108	2,628	535	4.30	21.12	0.52	2.56
131	11,612	8,356	433	3,166	1,190	638	9.76	18.20	0.36	0.68
132	11,825	8,709	732	4,662	1,602	410	7.38	28.84	0.46	1.79

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133	11,900	8,494	545	1,890	1,800	504	6.61	23.61	0.30	1.08
134	*12,388	*8,873	322	1,646	*6,000	*554	*2.06	*22.36	0.05	0.58
135	12,434	8,901	379	2,010	3,410	390	3.65	31.88	0.11	0.97
136	12,449	8,873	608	2,145	1,600	545	7.78	22.84	0.38	1.12
137	12,453	9,048	528	3,832	1,000	371	12.45	33.57	0.53	1.42
138	12,708	9,053	Not available	Not available	319	81	39.84	156.89	-	-
139	12,768	7,840	213	1,069	1,698	380	7.52	33.60	0.13	0.56
140	12,793	9,162	Not available	Not available	390	481	32.80	26.60	-	-
141	12,862	7,894	317	1,639	1,272	238	10.11	54.04	0.25	1.33
142	12,912	9,363	663	4,999	1,717	306	7.52	42.20	0.39	2.17
143	12,919	9,080	1,162	1,993	1,500	453	8.61	28.52	0.77	2.57
144	12,920	9,198	1,313	4,892	2,200	365	5.87	35.40	0.60	3.60
145	13,030	9,335	504	3,657	1,800	753	7.24	17.30	0.28	0.67
146	13,034	9,256	1,072	3,928	1,890	296	6.90	44.03	0.57	3.62

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147	13,158	9,196	115	1,268	1,297	483	10.14	27.24	0.09	0.24
148	13,183	9,618	748	5,683	1,743	497	7.56	53.46	0.43	1.51
149	*13,226	*8,118	260	1,258	*3,900	*446	*3.39	*29.65	0.07	0.58
150	13,239	9,481	284	2,132	930	693	14.24	19.10	0.31	0.41
151	13,322	9,759	792	6,591	2,788	565	4.78	23.58	0.28	1.40
152	13,378	9,596	251	1,373	2,800	465	4.78	28.77	0.09	0.54
153	13,447	9,626	152	994	1,842	421	7.30	31.94	0.08	0.36
154	13,494	8,282	108	614	1,650	603	8.18	22.38	0.07	0.18
155	13,590	9,713	358	2,216	2,634	389	5.16	34.94	0.14	0.92
156	13,616	8,360	295	1,419	2,100	509	6.48	26.75	0.14	0.58
157	13,886	8,516	458	3,663	1,830	417	7.59	33.30	0.25	1.10
158	14,014	8,598	343	2,446	2,546	625	5.50	22.42	0.13	0.55
159	*14,037	*10,882	Not available	Not available	*5,458	*441	*2.57	*31.83	-	-
160	14,104	8,648	Not available	Not available	1,872	385	7.53	36.63	-	-
161	14,115	10,412	185	1,273	2,440	429	5.78	32.90	0.08	0.43

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162	14,123	24,251	202	1,040	1,500	478	9.42	29.55	0.13	0.42
163	14,222	10,151	1,072	5,324	2,100	690	6.77	20.61	0.51	1.55
164	14,265	8,751	Not available	Not available	1,003	342	14.22	14.22	-	-
165	14,542	10,034	602	2,529	1,716	344	8.47	42.27	0.35	1.75
166	14,688	10,468	496	2,446	2,864	645	5.13	22.77	0.17	0.77
167	14,948	10,375	784	3,970	1,789	414	8.36	36.11	0.44	1.89
168	15,001	10,685	467	2,237	1,650	563	9.09	26.64	0.28	0.83
169	15,273	10,822	**2,452	**15,578	**2,500	**629	6.11	24.28	*0.98	3.90
170	15,280	11,079	544	3,795	2,000	405	7.64	37.73	0.27	1.34
171	15,495	9,512	472	2,300	1,050	451	14.76	34.36	0.45	1.05
172	15,570	11,090	203	923	1,500	589	10.38	26.43	0.14	0.34

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173	15,578	11,033	731	2,587	2,100	602	7.42	25.88	0.35	1.21
174	15,850	11,491	642	5,683	2,040	365	7.77	43.42	0.31	1.76
175	15,854	11,499	325	2,040	2,547	555	6.22	7.52	0.13	0.59
176	15,857	11,080	Not available	Not available	225	91	70.48	174.25	0.00	
177	*15,978	*9,816	992	5,380	*6,000	*546	*2.66	*29.26	0.17	1.82
178	15,995	11,052	485	2,895	2,280	758	7.02	21.10	0.21	0.64
179	16,173	11,367	683	1,004	1,450	366	11.15	44.19	0.47	1.87
180	16,192	11,930	133	884	1,200	432	13.49	37.48	0.11	0.31
181	16,323	11,472	**1,558	**3,279	**1,240	**450	13.16	36.27	**1.26	**3.46
182	16,643	12,011	Not available	Not available	1,920	505	8.67	32.96	-	-
183	16,704	10,244	320	2,271	2,403	486	6.95	34.37	0.13	0.66
184	16,750	11,884	Not available	Not available	2,100	550	7.98	30.45	-	-
185	16,798	11,645	Not available	Not available	263	107	63.87	156.99	-	-
186	17,057	12,071	Not available	Not available	540	484	31.59	35.24	-	-
187	*17,084	*9,415	387	2,412	*10,723	*498	*1.59	*9.59	0.04	0.78
188	17,121	12,404	121	687	932	421	18.37	40.67	0.13	0.29
189	*17,527	*13,171	330	2,701	*3,912	*374	*4.48	*46.86	0.08	0.88
190	17,607	12,374	1,174	2,549	2,335	446	7.54	39.48	0.50	2.63

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191	17,729	12,460	**1,817	**4,082	**3,192	**652	5.55	27.19	**0.57	**2.79
192	18,113	12,841	397	2,021	850	606	21.31	29.89	0.47	0.66
193	18,172	13,200	1,034	2,852	1,305	324	13.92	56.09	0.79	3.19
194	18,303	12,959	1,024	5,028	1,350	684	13.56	26.76	0.76	1.50
195	18,357	12,666	735	3,165	1,170	163	15.69	112.62	0.63	4.51
196	18,505	13,106	207	2,053	1,850	538	10.00	34.40	0.11	0.38
197	19,202	13,597	311	1,595	1,100	558	17.46	34.41	0.28	0.56
198	19,283	15,092	590	1,513	2,940	292	6.56	66.04	0.20	2.02
199	19,326	13,989	**329	**2,402	**2,574	**855	7.51	22.60	**0.13	**0.38
200	19,596	12,029	1,249	6,802	1,500	360	13.06	54.43	0.83	3.47
201	20,224	14,534	**2,038	**17,263	**1,544	**393	13.10	51.46	**1.32	**5.19
202	20,400	14,337	**2,927	**6,808	1,800	358	11.33	56.98	**1.63	**8.18
203	20,519	14,703	689	5,111	2,885	266	7.11	77.14	0.24	2.59

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204	20,728	14,296	Not available	Not available	486	96	42.65	215.92	-	-
205	22,198	15,923	**1,595	**14,467	**1,800	**585	12.33	37.95	**0.89	**2.73
206	22,603	16,196	371	3,072	1,914	700	11.81	32.29	0.19	0.53
207	22,839	16,118	643	3,096	2,400	669	9.52	34.14	0.27	0.96
208	*23,094	*16,281	**358	**1,865	***4,500	***840	*5.13	*27.49	**0.08	*0.43
209	*24,073	*17,289	**1,879	**10,750	***4,400	***628	*5.47	*38.33	**0.43	**2.99
210	24,602	17,947	Not available	Not available	587	301	41.91	81.73	-	-
211	25,230	19,241	**1,390	**6,640	**2,000	**	12.62	45.71	**0.70	**2.52
212	25,629	19,135	442	2,939	1,836	434	13.96	59.05	0.24	1.02
213	26,191	18,847	**2,754	**19,636	**1,360	**465	19.26	56.32	**2.03	**5.92
214	26,542	19,963	Not available	Not available	1,812	383	14.65	69.30	-	-
215	26,559	19,052	335	2,024	2,500	411	10.62	64.62	0.13	0.82
216	*26,568	*18,844	691	5,163	*4,885	*292	*5.44	*90.99	0.14	2.37
217	*29,520	*21,378	365	2,315	*800	*523	*37.49	*57.34	0.46	0.70
218	*29,966	*21,025	Not available	Not available	*3,000	*282	*9.99	*106.26	0.03	0.35
219	*31,246	*27,701	**1,540	**12,750	***2,415	***604	*12.96	*43.97	**0.64	**2.55
220	*34,500	*24,677	**2,324	**15,650	***2,250	***538	*15.33	*64.13	**1.03	**4.32
221	*35,788	*25,934	731	1,369	*1,200	*199	*29.82	*179.84	0.61	3.67
222	*37,125	*22,767	552	4,743	*4,400	*505	*8.44	*73.51	0.13	1.09

School Number	Annual Electricity Consumption (kWh)	Annual Energy Cost (ILS)	Annual Water Consumption (m^3)	Annual Water Cost (ILS)	Built-up Area (m^2)	No. of Students	Building Energy Index per Meter Square ($kWh/m^2/year$)	Building Energy Index per student (kWh/Student/year)	Water Use Intensity per Meter Square ($m^3/m^2/year$)	Water Use Intensity Per Student (m^3/Student/year)
223	*39,348	*27,511	**248	**1,157	***1,548	***847	*25.42	*46.46	**0.16	**0.29
224	*40,061	*51,958	Not available	Not available	*557	*145	*71.92	*276.28	-	-
225	*48,293	*31,376	Not available	Not available	*1,345	*666	*35.91	*72.51	-	-

* Outlier value was excluded based on the analysis of annual energy consumption

** Outlier value was excluded based on the analysis of annual water consumption

***Outlier value was excluded based on the analysis of annual energy and water consumption

Stage 4: Five Number Analysis (Min, Q1, Q2, Q3, Max) was applied on the data of the annual energy consumption to identify and exclude the potential outliers to reduce the variation in the data. The median (Q2) was calculated to identify the center of the data set. Also, the lower quartile (Q1) and the upper quartile (Q3) were calculated to find the interquartile range. In addition, the minimum and the maximum values were used to present the true dispersion of the data (Weiss, 2011). The analysis was performed by following the below steps:

a) The data of the annual electricity consumption was sorted in an ascending order and was numbered from 1 to 225.

b) The median value of the number of schools was calculated using the following equation (Weiss, 2011):

   Median = (n + 1 / 2)

   Where n is the sample size. The result of that equation was (225+1)/2 = 113, so the median value of the annual electricity consumption was 10,270 kWh/year, which was opposite to reading number 113 as shown in Table 4.3 above. Also, this value divided the data into two equal halves.

c) Q1 and Q3 were calculated by repeating equation above on the resulted halves from step (b). The value of Q1 was 7,125.5 kWh/year and the value of Q3 was 15,276.5 kWh/year.

d) Interquartile range (IQR) was calculated by subtracting Q3 from Q1 (Q3-Q1). The value of IQR was 15,276.5-7,125.5= 8,151 kWh/year.

e) Interquartile interval was developed to identify the outliers by calculating the lower and the upper boundaries of this interval using the following equations (Weiss, 2011):

Lower boundary = Q1-1.5*IQR

Upper boundary = Q3+1.5*IQR

The lower boundary was 7,125.5-1.5*8,151= -5,101 kWh/year and the upper boundary was 15,276.5+1.5*8,151= 27,503 kWh/year. Then, any value did not fall in the interval was excluded. The outliers of annual energy consumption are marked with an asterisk (*) in Table 4.3 above. The results of steps (b) to (e) are summarized in Table 4.4 below.

Table 4.4: Five Number Summary Analysis of the Data of the Annual Energy Consumption before Excluding the Outliers (kWh/year)

Min	Q1	Q2	Q3	Max	IQR	Lower Bound	Upper Bound
577	7,125.5	10,270	15,276.5	48,293	8,151	-5,101	27,503

In addition to the Table above, the histogram and the boxplot below were plotted to provide an indication about the data related to the annual consumption of electricity before excluding the outliers. The histogram showed that the data of the annual energy consumption has a skewed shape to the left, while the boxplot illustrates the potential outliers as shown in Figure 4.1 and Figure 4.2.

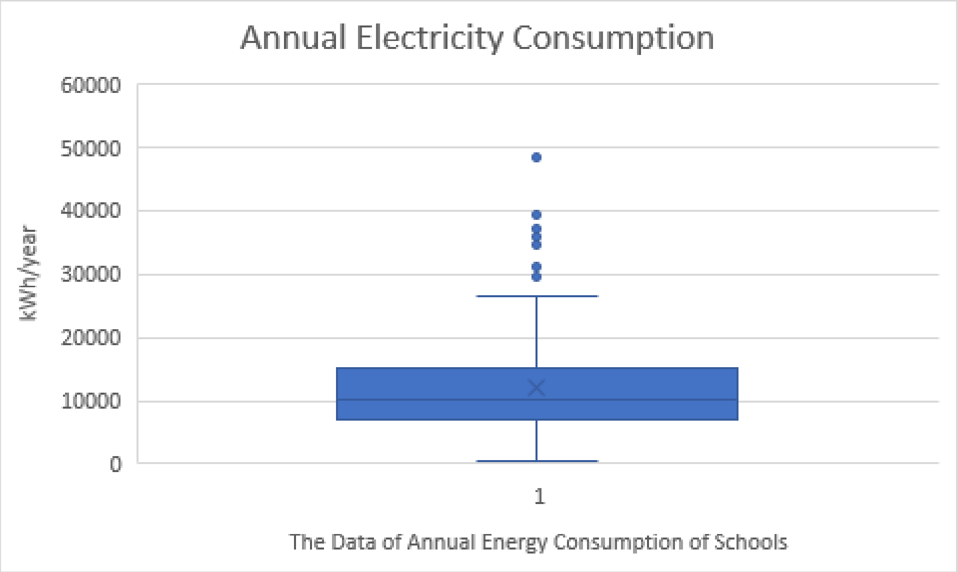

Figure 4.1: Boxplot for the Data of the Annual Energy Consumption before Excluding the Outliers

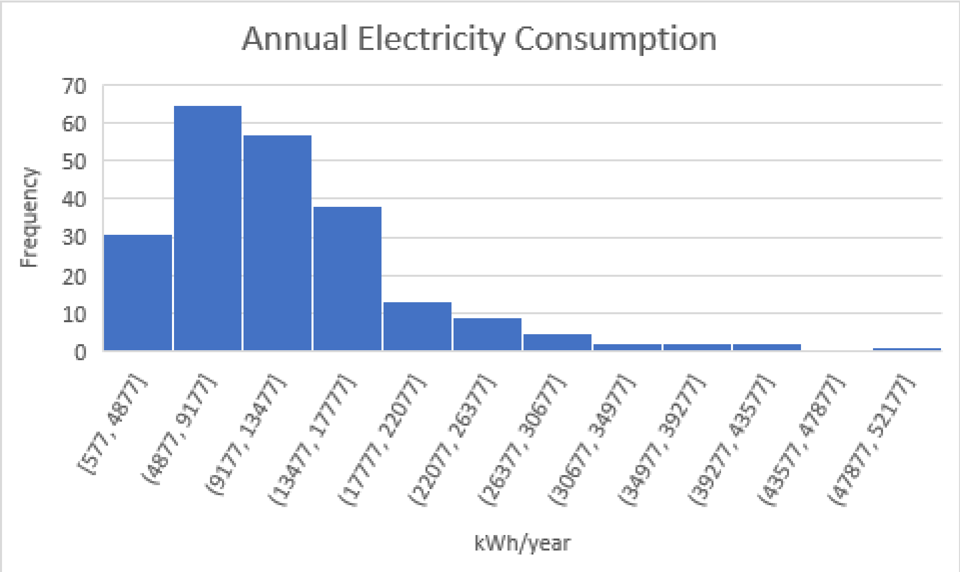

Figure 4.2: Histogram for the Data of the Annual Energy Consumption before Excluding the Outliers

According to Figure 4.3 below which represents the variation in the data of the annual energy consumption before excluding the outliers of the data, the maximum and the minimum values of the annual energy consumption were 48,293 kWh/year and 577 kWh/year respectively.

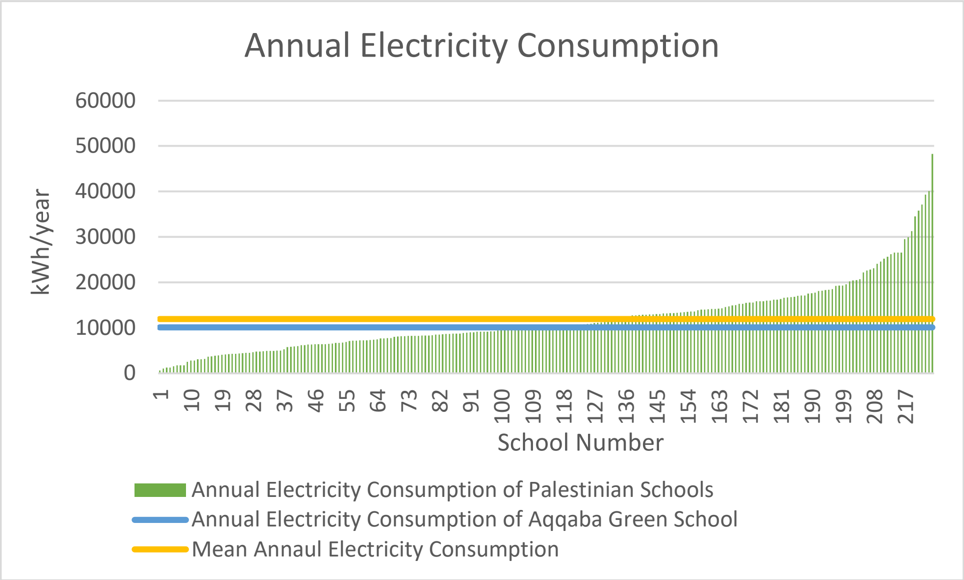

Figure 4.3: The variation of the Data of the Annual Energy Consumption before Removing the Outlier Values

f) After excluding the data points of schools that were identified as outliers, five number summary analysis was repeated on the data of built-up areas of schools that remained from the previous analysis to reduce the variation in the data. The results of this step are summarized in Table 4.5 below:

Table 4.5 : Five Number Summary Analysis for the Data of the Areas of Schools before Excluding the Outliers (meter square)

Min	Q1	Q2	Q3	Max	IQR	Lower Bound	Upper Bound
105	952.5	1,500	2,082	10,723	1,129.5	-741.75	3,776.25

According to Figure 4.4 and Figure 4.5 below, the maximum data point of built-up areas of schools in the original data was 10,723 m², while the maximum data point after excluding the outlier values of built-up areas was 3,410 m². The outliers of area data marked with an asterisk (*) in Table 4.3 above.

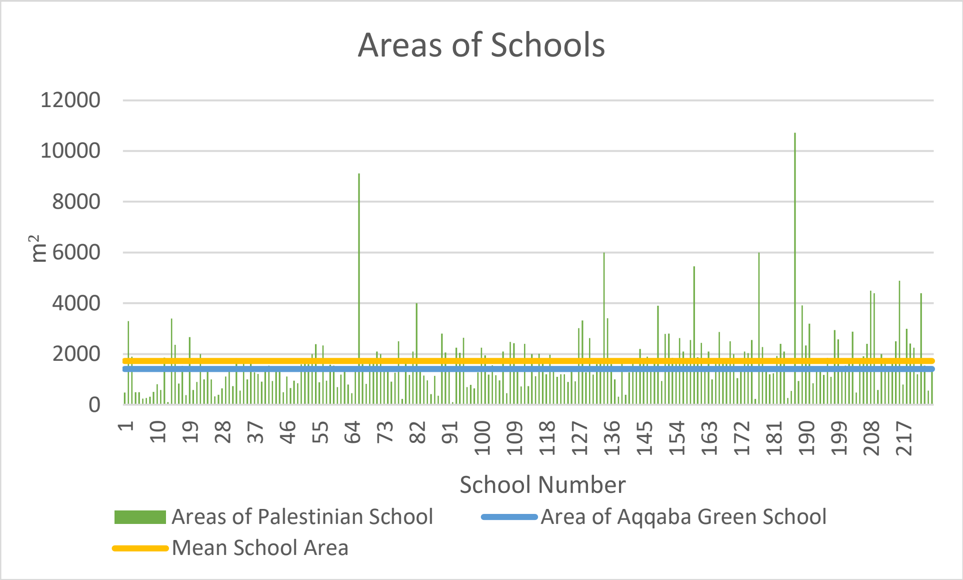

Figure 4.4: The variation in the Data of the Areas of Schools before Excluding the Outliers

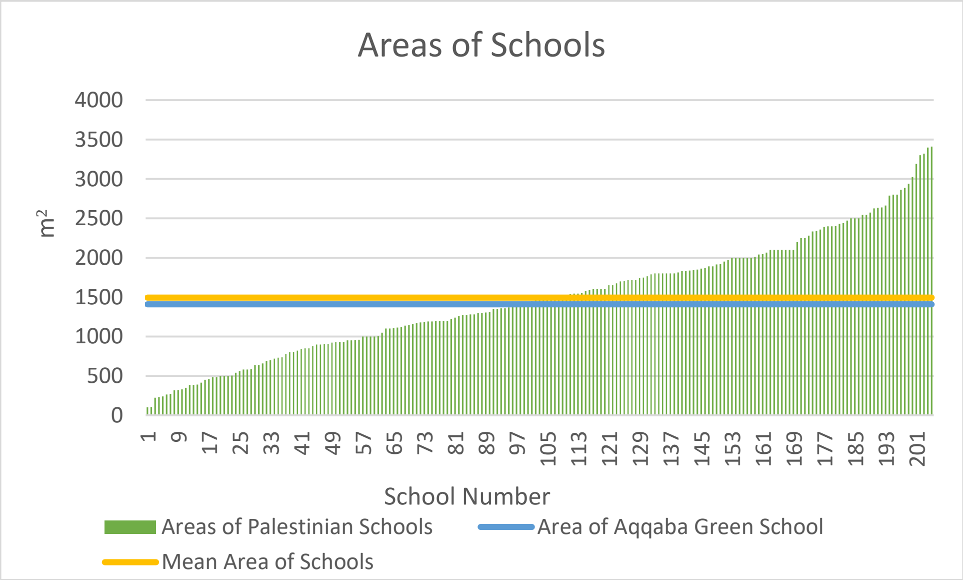

Figure 4.5: The variation in the Data of the Areas of Schools after Excluding the Outliers

g) Finally, five number summary analysis was made on the final data of the annual energy consumption remaining from step (f) as shown in Table 4.6 below:

Table 4.6: Five Number Summary Analysis for the Final Data of the Annual Energy Consumption (kWh/year)

Min	Q1	Q2	Q3	Max
577	6,593	9,849	14,059	26,559

Also, the following histogram and boxplot provides an indication about the distribution of the remaining data of the annual electricity consumption, after excluding the outliers as shown in Figure 4.6 and Figure 4.7.

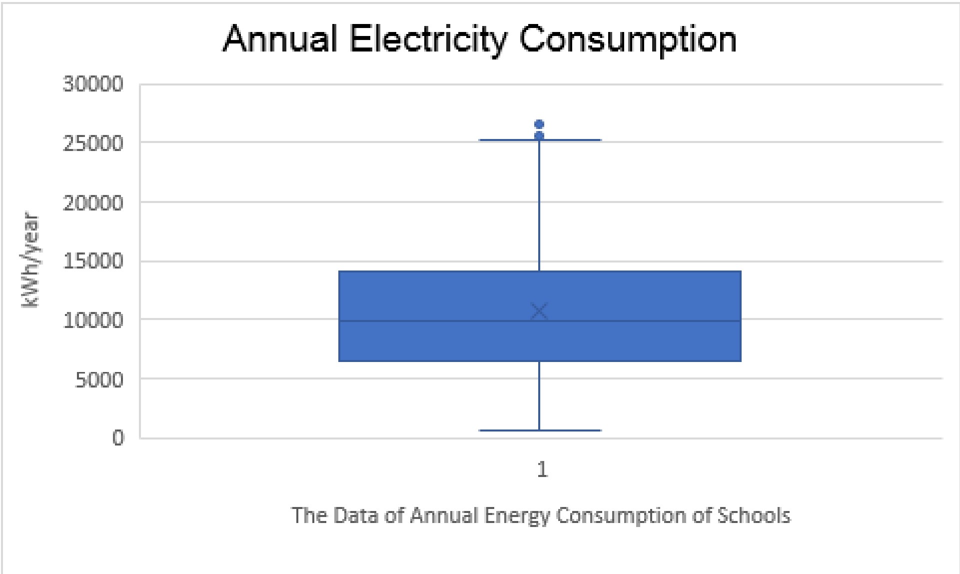

Figure 4.6: Boxplot for the Final Data of the Annual Energy Consumption

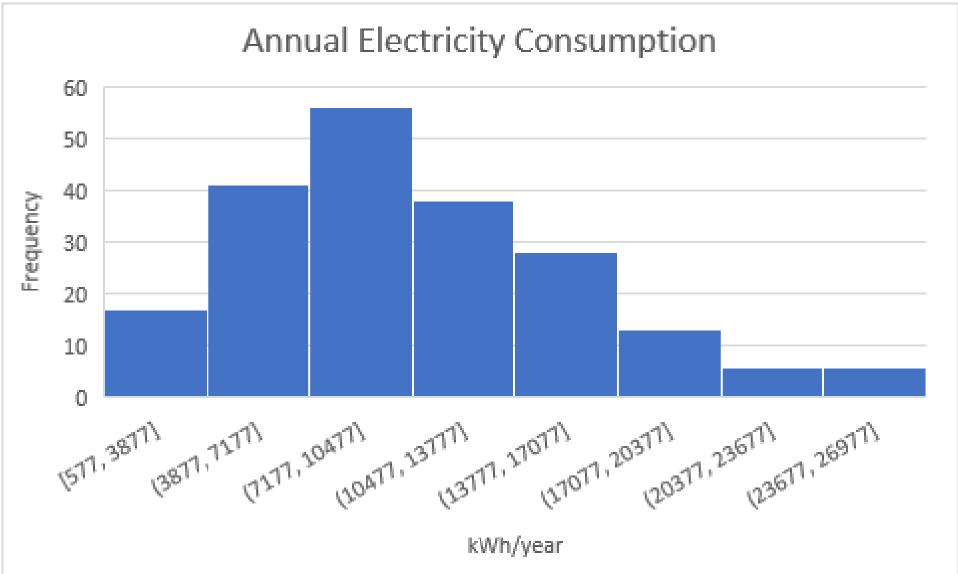

Figure 4.7: Histogram for the Final Data of the Annual Energy Consumption

According to Figure 4.8 below, the maximum value of the annual energy consumption after excluding the outliers was 26,559 kWh/year, while the maximum value before excluding the outliers was 48,293 kWh/year.

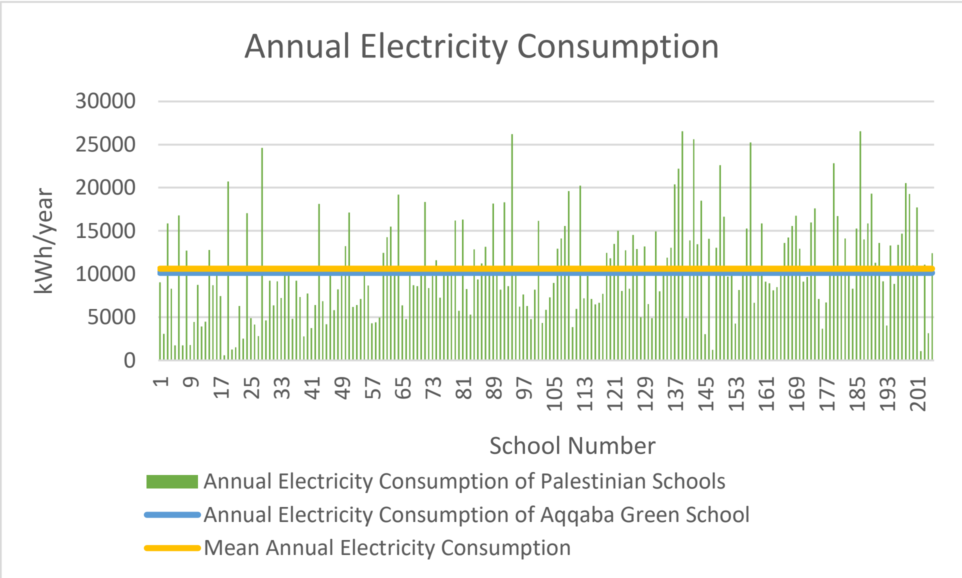

Figure 4.8: The variation in the Final Data of the Annual Energy Consumption

Stage 5: Descriptive statistics were applied on the remaining data of the annual energy consumption, and confidence intervals were developed with confidence levels of 95% and 99% respectively using 1- sample t method as shown in Table 4.7 below. The 1-sample t method was the appropriate method to be used because it depends on the sample mean and the sample standard deviation instead of depending on the mean and the standard deviation of the whole population (Weiss, 2011).

Table 4.7: Descriptive Statistics and Confidence Intervals for the Final Data of the Annual Energy Consumption

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	205	kWh/year	10,639	5,534	9,876	11,401	9,634	11,644	10,124
Annual Electricity Cost	205	ILS	7,748	4,141	7,178	8,318	6,996	8,500	7,175
Building Energy Index	205	kWh/m²/year	9.56	10.53	8.11	11.01	7.65	11.47	7.19
Annual Electricity Consumption Per Student	205	kWh/student/year	31.39	26.25	27.78	35	26.62	36.16	65
Area	205	m²	1,496	740.09	1,394	1,598	1,362	1,631	1,408
Students Number	205	Student	394	162	371	416	364	423	156

According to Table 4.7 above:

1- The true mean value of the annual electricity consumption of non-green schools in Palestine is predicted to fall in the interval of (9,876 – 11,401) kWh/year with confidence level of 95%, and is predicted to fall in the interval of (9,634 – 11,644) kWh/year with confidence level of 99%, while the annual electricity consumption of Aqqaba Green School is 10,124 kWh/year, which falls within the two intervals. It is worth mentioning that the total electricity demand of the green school is supplied through the installed PV system (see section 4.1 above).

2- The true mean value of the annual electricity cost of non-green schools in Palestine is 95% lies in the interval of (7,178 – 8,381) ILS and 99% lies in the interval of (6,996 – 8,500) ILS, while the annual electricity consumption cost of Aqqaba Green School is 7,175 ILS, which falls in the 99% confidence interval and slightly less than the lower limit of the 95% confidence interval. It is worth noting that the annual electricity consumption cost of the green school (7,175 ILS) in its first year of operation represents the billed amount by the utility service provider. However, the green school, through its PV system, has generated more energy than consumed by 4,426 kWh/year (See section 4.1 above), which equivalent to around 2,297 ILS. This implies that the total energy revenue exceeds the energy cost by 2,297 ILS in the first year of operation.

3- The analysis of the data of BEI of non-green schools in Palestine predicted that the mean of BEI 95% falls in the interval of (8.11-

11.01) kWh/m²/year, and 99% falls in the interval of (7.65 - 11.47) kWh/m²/year, while the BEI of Aqqaba Green School is 7.19 kWh/m²/year, which is less than the lower boundaries of both intervals.

4- The true mean value of the annual electricity consumption per student of non-green schools in Palestine is 95% expected to fall in the interval of (27.78 - 35) kWh/student/year, and 99% expected to fall in the interval of (26.62 - 36.16) kWh/student/year, while the annual electric consumption per student of the green school is 65 kWh/student/year, which is higher than the two upper limits of the two intervals. However, the higher energy consumption per student can be attributed to the fact that the current number of students in Aqqaba Green School is less than the half of the estimated sample mean.

5- Aqqaba Green School consumed less energy than the average annual electricity consumption of non-green schools in Palestine by 515 kWh/year with energy saving percentage of 4.84%. To calculate the actual savings in cost, the amount of energy savings was multiplied by the local tariff of Aqqaba Village which was 0.692 ILS/kWh, so the actual savings in cost was 515 kWh/year x 0.692 ILS/year = 356.40 ILS/year. And since the green school has a grid connected PV system that exported around 14,550 kWh to the grid in the first year of operation which is economically equivalent to 10,068.60 ILS (14,550 kWh/year x 0.692 ILS/kWh), and in return consumed 10,124 kWh in the same year which is equivalent to 7,175 ILS according to the electricity bills. It can be concluded that the actual energy cost of the green school is entirely offset by the generated energy through the PV system and, in addition, the surplus energy forms a revenue of 2,297 ILS/year for the school calculated as follow:

Total net exported energy – Total billed energy consumption) x 0.75 x 0.692 =

(14,550 kWh/year – 10,124 kWh/year) x 0.75 x 0.692 ILS/kWh = 2,297 ILS.

The utility service provider only accounts for 75% of the exported energy to the grid.

6- The annual electricity consumption per student at Aqqaba Green School is higher than the same variable for the non-green schools by 33.61 kWh/Student/year with a percentage of 107%.

The explanation of the resulting energy savings is due to the built-up area and the number of students of Aqqaba Green School. According to results summarized in Table 4.7 above, the average values of built-up areas and for number of students in the sample were 1,496 m² and 394 students respectively, while the built-up area and the number of students of the green were 1,408 m² and 156 students, so the number of students and the built-up area of the green school were less than the mean values by 88 m² and 238 students with different percentage of 5.88% and 60.4% respectively.

The data related to the annual consumption of water was analyzed using the same procedures and stages that were followed in analyzing the data related to the annual consumption of energy. The first three stages are common, while stage 4 and stage 5 were repeated based on the data of the annual water consumption as follows:

a) The data of the annual water consumption was sorted in ascending order.

b) Five number summary analysis was applied on the data of the annual water consumption to define the outlier values of the annual water consumption as shown in Table 4.8 below.

Table 4.8: Five Number Summary analysis for the Data of the Annual Water Consumption before Excluding the Outliers (m^3/year)

Min	Q1	Q2	Q3	Max	IQR	Lower Bound	Upper Bound
100	261	387.5	686	2,927	425	-376.5	1,323.5

The following boxplot (Figure 4.9) histogram (Figure 4.10) show a high degree of variation in the data of the annual water consumption before excluding the outliers. The outliers are marked with an asterisk (**) in Table 4.3 above

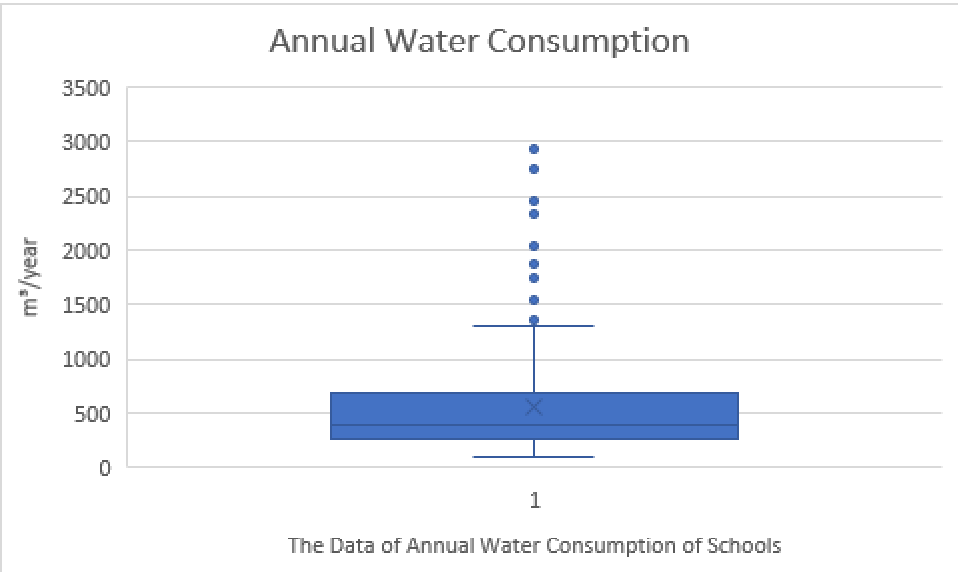

Figure 4.9: Boxplot for the Initial Data of the Annual Water Consumption

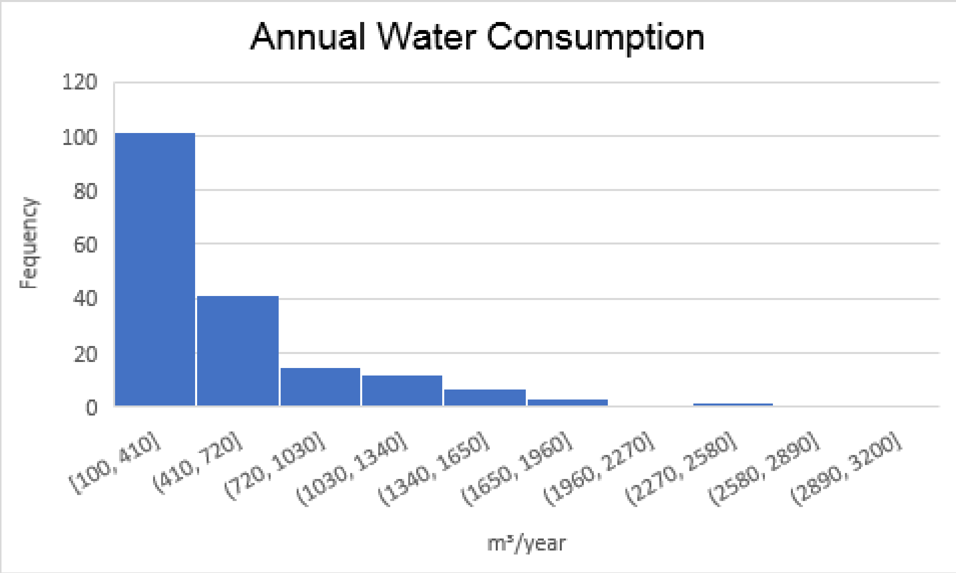

Figure 4.10: Histogram for the Initial Data of the Annual Water Consumption

Also, Figure 4.11 below shows that the maximum value for annual water consumption before excluding the outliers was 2,927 m³/year, while the minimum annual water consumption 100 m³/year.

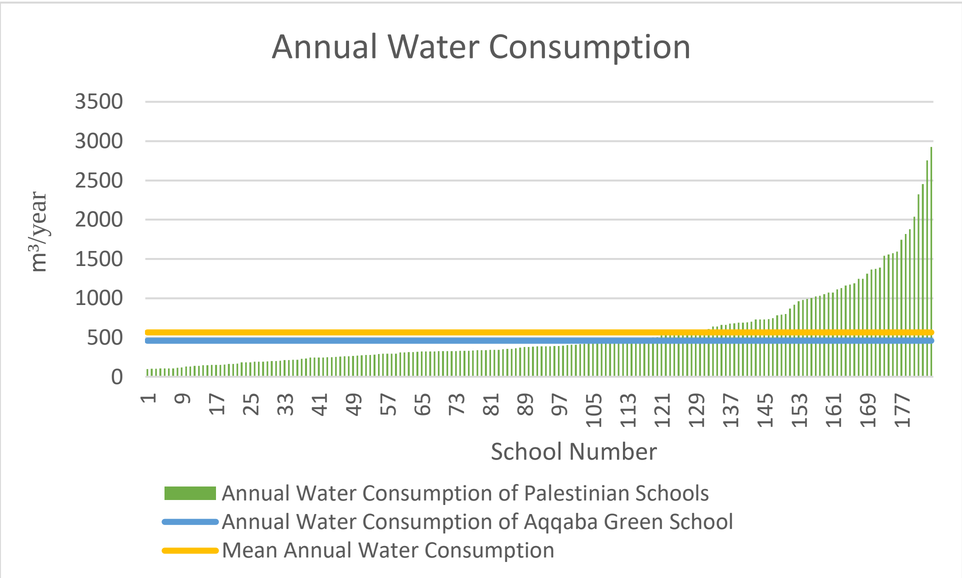

Figure: 4.11 The variation in the Initial Data of the Annual Water Consumption

c) After removing the data of the outliers, five number summary analysis was repeated on the data of number of students to exclude the outliers and to reduce the variation in the data as summarized in Table 4.9. The outliers are marked with an asterisk (**) in Table 4.3 above

Table 4.9: Five Number Summary Analysis for the Initial Data of the Number of Students (student)

Min	Q1	Q2	Q3	Max	IQR	Lower Bound	Upper Bound
39	316	411	521.5	855	205.5	8	830

According to Figure 4.12 and Figure 4.13 below, the maximum number of students before excluding the outliers was 855 students, while the maximum number of students after excluding the outlier values was 758 students.

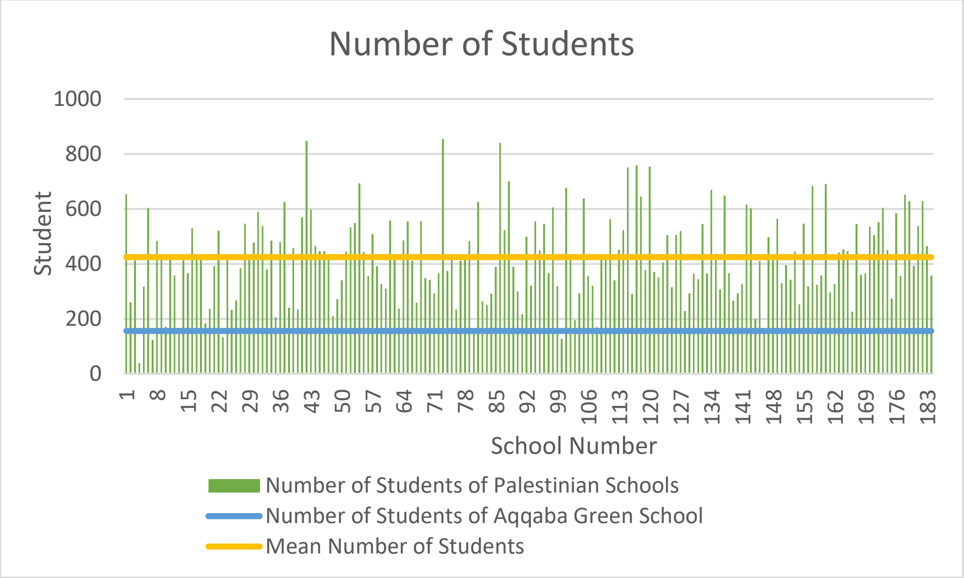

Figure 4.12: The variation in the Initial Data of the Number of Students

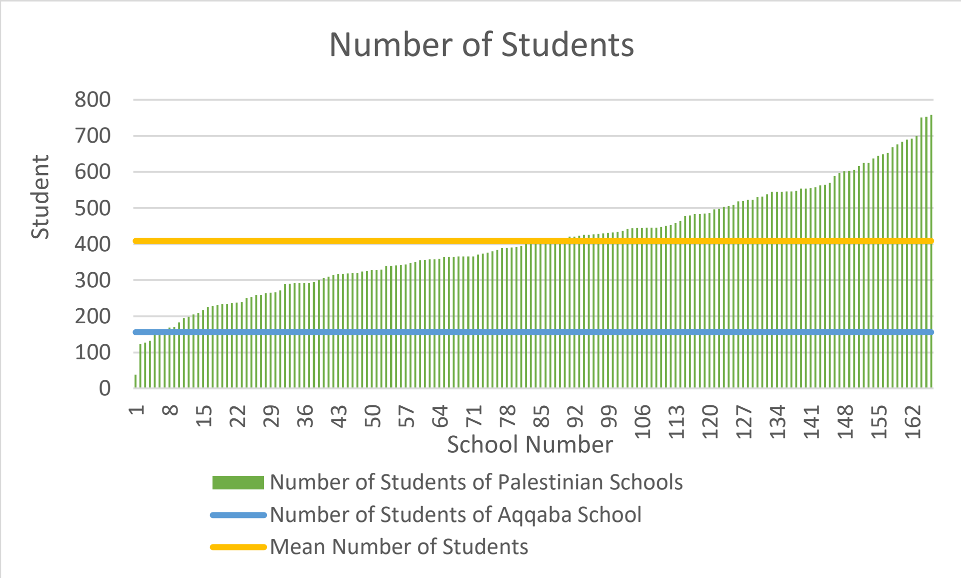

Figure 4.13: The variation in the Final Data of the Number of Students

d) The remained data of the annual water consumption was analyzed using five number summary method to provide information about the data as shown in Table 4.10 below.

Table 4.10: Five Number Summary Analysis for the Final Data of the Annual Water Consumption (m³/year)

Min	Q1	Q2	Q3	Max
100	250	361.5	578	1,313

In Addition, the following histogram and boxplot represent the distribution shape and the status of the outlier values after excluding the outliers as shown in Figure 4.14 and Figure 4.15 below.

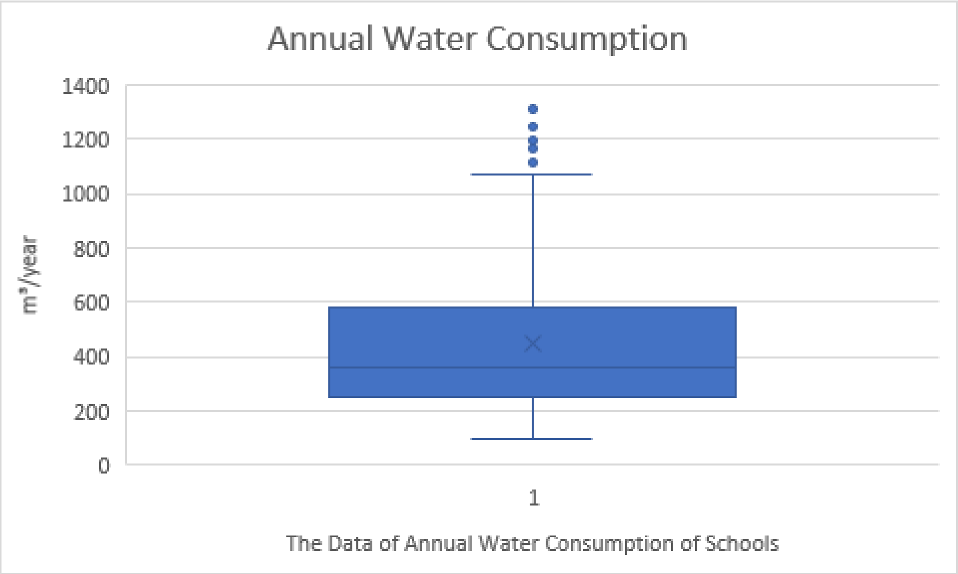

Figure 4.14: Boxplot for the Final Data of the Annual Water Consumption

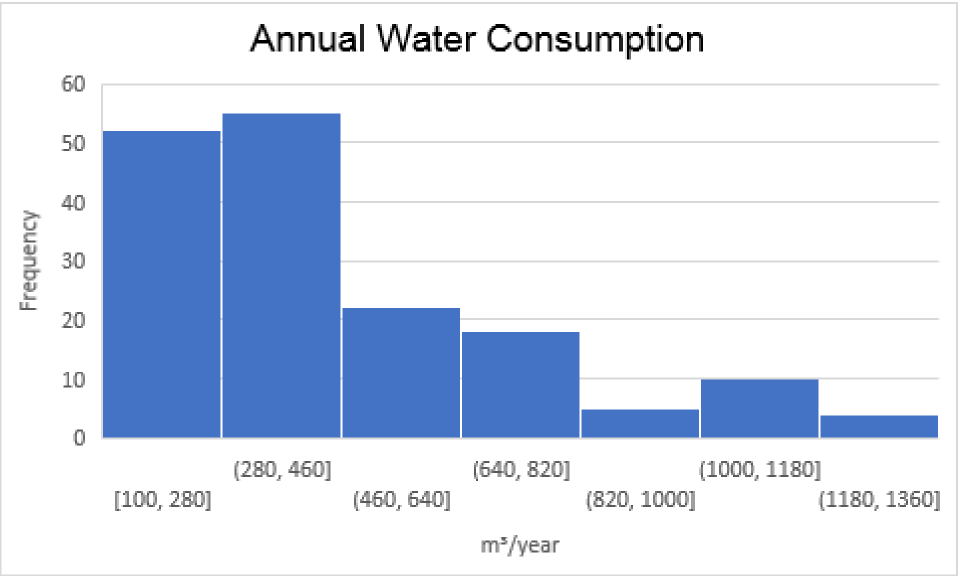

Figure 4.15: Histogram for the Final Data of the Annual Water Consumption

According to Figure 4.16 below, the maximum value of annual water consumption after excluding the values of the outliers was 1,313 m³/year, while the maximum value before excluding the outliers was 2,927 m³/year.

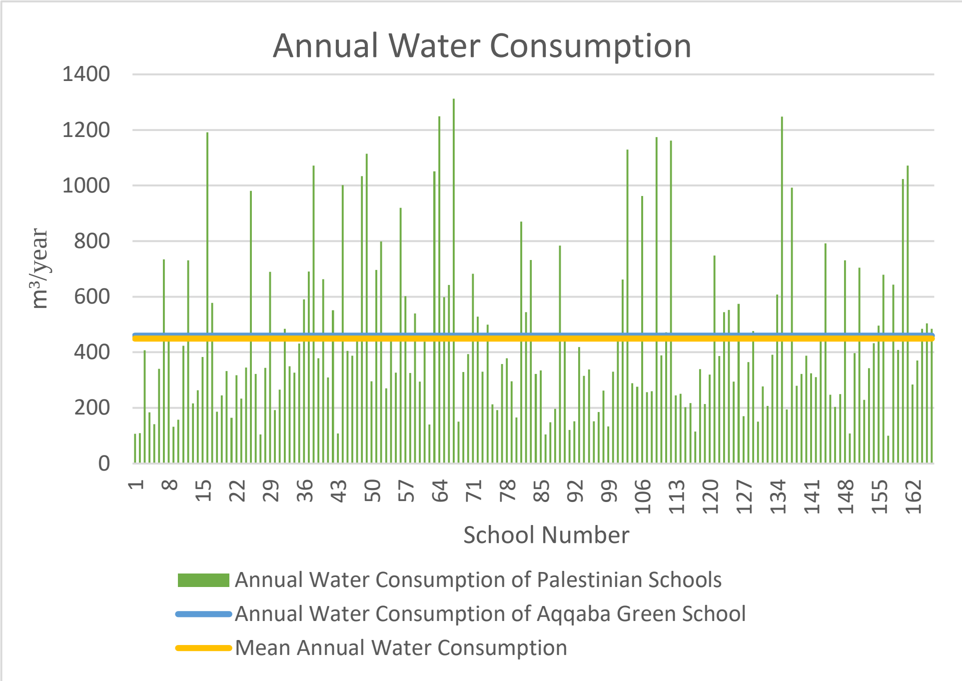

Figure 4.16: The variation in the Data of the Final Water Consumption

e) Finally, descriptive statistics were calculated for the remained data in addition to confidence intervals, as shown in Table 4.11 below.

Table 4.11: Descriptive Statistics and Confidence intervals of the Final Data of the Annual Water Consumption

					CI 95%		CI 99%		Aqqaba School
Item	Unit	n	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Water Consumption	m^3/year	166	450	287	406	494	392	508	460
Annual Water Cost	ILS	166	2,388	1,660	2,134	2,643	2,053	2,724	3,278
Annual Water Consumption Per m^2	m^3/m^2/year	166	0.33	0.26	0.29	0.37	0.27	0.38	0.33
Annual Water Consumption Per Student	m^2/Student	166	1.25	0.93	1.11	1.39	1.06	1.43	2.95
Area	m^2	166	1,805	1,312	1,604	2,006	1,540	2,070	1,408
Student Number	Student	166	409	145	387	431	380	438	156

According to Table 4.11 above:

1- The results indicate that the true mean value of annual water consumption in non-green schools in Palestine is predicted to fall in the interval of (406 - 494) m^3/year with confidence level of 95% and is predicted to fall in the interval of (392 - 508) m^3/year with confidence level of 99%, while the annual water consumption in Aqqaba Green School is 460 m^3/year, which lies in both intervals.
2- The results indicate that the true mean value of the annual water cost of non-green schools in Palestine is 95% predicted to fall in the interval of (2,134 – 2,643) ILS/year and 99% is predicted to fall in the interval of (2,053 – 2,724) ILS/year, while the annual water consumption cost of the green school is 3,278 ILS, which is higher than the upper limits of the two intervals.
3- The true mean annual water consumption per m^2 of non-green schools in Palestine is 95% lies in the interval of (0.29 - 0.37) m^3/m^2/year and 99% lies in the interval of (0.28 - 0.38) m^3/m^2/year, while the annual water consumption per m^2 of Aqqaba Green School is 0.33 m^3/m^2/year, which lies in the two intervals.
4- The true mean value of the annual water consumption rate per student in non-green schools in Palestine is 95% expected to be in the interval of (1.11 - 1.39) m^3/student/year and 99% is expected to be in the interval of (1.06 - 1.43) m^3/student/year, while the annual water consumption per student in the green school is 2.95 m^3/student/year, which is higher than the two upper limits of the two intervals.

5- Aqqaba Green School consumed more cubic meters of water than the average water consumption in the Palestinian non-green schools in the sample by 10 m³/year with percentage of 2.2%, and that extra consumption is due at first, to the existence of green areas at the green school and second, to the usage of the school in summer semester.

6- Aqqaba Green School has no savings on the annual rate of water consumption cost compared to the average consumption cost of non-green school in the sample.

7- The value of water use intensity per student in the green school was higher than the average intensity by 136% because the number of students in the green school was less than the average number of students by 253 students with difference percentage of 61.86%.

4.2.2 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Secondary Schools in the West Bank

In the previous analysis, the actual energy and water consumption performance of Aqqaba Green School was measured against the actual performance of all school categories included in the sample which include both secondary and elementary schools. In other words, in the previous analysis, regardless the category, the general performance of all schools was used as a baseline to measure the actual performance of the green school.

However, since Aqqaba Green School is a secondary school, the comparison can be more meaningful by replicating the analysis taking into consideration secondary schools only, as the energy and water usage patterns are expected to be similar within the same category of schools. Based on the above, the analysis was replicated using secondary schools only as a baseline.

The replication of the analysis was conducted on a sample that contains 79 secondary schools for males and females, located in different geographical areas in West Bank. According to the results of replicating the analysis considering these schools as the baseline which are summarized in Table 4.12 below, Aqqaba Green School consumed less energy than the average annual energy consumption for these secondary schools by 2,194 kWh/year with energy saving percentage of 17.8%. This energy saving corresponds to a cost savings of 1,518.25 ILS per year (without considering the revenue obtained through the exported energy form the PV system). Similarly, the annual water consumption level for the green school is less by 39 m^3/year than that of similar schools in the sample with difference percentage of 7.82%. Table 4.12 below provides a summary of Aqqaba Green School energy and water consumption levels in comparison with similar secondary schools in the sample.

Table 4.12: Aqqaba Green School Performance against Secondary Schools in the Sample

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	79	kWh/year	12,318	5,104.81	11,174	13,461	10,801	13,834	10,124
Annual Electricity Cost	79	ILS	8,843.57	4,105.64	7,924	9,763	7,624	10,063	7,175
Building Energy Index	79	kWh/m²/year	8.18	4.94	7.07	9.28	6.71	9.64	7.19
Annual Electricity Consumption Per Student	79	kWh/student/year	31.39	17.02	27.57	35.2	26.33	36.44	65
Area	79	m²	1,757.09	681.75	1,604.4	1,909.8	1,554.6	1,959.6	1,408
Students Number	79	Student	417	132	387	446	378	456	156
Annual Water Consumption	74	m³/year	499	341.33	419.9	578.1	394.1	604	460
Annual Water Cost	74	ILS	2,576	1,855.15	2,147	3,006	2,006	3,147	3,278
Annual Water Consumption Per M2	74	m³/m²/year	0.316	0.299	0.25	0.39	0.22	0.41	0.33
Annual Water Consumption Per Student	74	m³/Student/year	1.35	1.07	1.1	1.59	1.02	1.67	2.95
Area	74	m²	2,041	1,407	1,715	2,367	1,609	2,474	1,408
Students Number	74	Student	413	122	385	441	375	450	156

4.2.3 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Female Secondary Schools in the West Bank

The previous analysis was made on the data for males and females secondary schools to compare the actual performance of Aqqaba Green School with the baseline of these schools. Additional analysis was repeated on the data of female secondary schools only, which are located in different geographical areas in the West Bank to compare the performance of the green school with the performance of other female secondary schools because the students of these school have the similar behavior. Table 4.13 below indicates that the green school consumed less energy than the average annual energy consumption by 2,916 kWh/year with energy saving percentage of 22.36% and cost savings of 2,017.87 ILS per year (without considering the revenue obtained through the exported energy form the PV system, and also, Aqqaba Green School consumed less water than the average annual water consumption by 166 m^3/year with difference percentage of 26.52%.

Table 4.13: Aqqaba Green School Performance against a Sample of Female Secondary Schools in the West Bank

					95% CI		99 % CI		Aqqaba School
Item	Unit	n	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	kWh/year	34	13,040	5,698.5	11,051.6	15,028.2	10,368.7	15,711.1	10,124
Annual Electricity Cost	ILS	34	9,081.74	4,106.77	7,648.84	10,514.7	7,156.68	11,006.8	7,175
Building Energy Index	kWh/m²/year	34	7.13	4.27	5.64	8.62	5.13	9.13	7.19
Annual Electricity Consumption Per Student	kWh/Student/year	34	27.13	14.52	22.065	32.195	20.325	33.935	65
Area	m²	34	2,294	1,175	1,684	2,905	1,474	3,115	1,408
Students Number	Student	34	459	114	419	499	405	513	156
Annual Water Consumption	m³/year	32	626	649	392	860	311	941	460
Annual Water cost	ILS	32	3,372	4,205	1,856	4,888	1,332	5,412	3,278
Annual Water Consumption Per M2	m³/m²/year	32	0.33	0.39	0.19	0.47	0.14	0.52	0.33
Annual Water Consumption Per Student	m³/student/year	32	1.387	1.325	0.91	1.87	0.75	2.03	2.95

4.2.4 Performance Measurement of Aqqaba Green School in Comparison to the Performance of Other Schools Based on the Climatic Zone

The previous analysis had been made on data from a sample of female secondary schools due to the similarity in the behavior of the students of Aqqaba Green School with these schools. It is healthy to repeat the same analysis after dividing the schools in the sample based on the climatic zones where each group of schools is located.

According to the book of "Guidelines for Energy Efficient Building Design (GEEBD)" (2004), West Bank can be divided into five climatic zones which are: A) hot dry summer, warm winter. B) Hot dry summer, mild winter. C) Hot semi-dry summer, temperate winter. D) Warm sub-humid summer, cold winter. E) Warm sub-humid summer, temperate winter.

4.2.4.1 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Schools in Climatic Zone (I)

Climatic Zone (I) has a climate of hot dry summer and mild winter. This zone is located at dry and very dry regions especially along Jordan Valley and around the Dead Sea. In summer the temperature could reach 38°C or higher, and in winter the temperature could drop to 15°C. The only city that is located in this zone is Jericho (GEEBD, 2004). Based on the analysis results of data of schools located in climatic zone (I) which is summarized in Table 4.14 below, Aqqaba Green School consumed less energy than the baseline of annual energy consumption by 13,380 kWh/year with energy saving percentage of 57% and cost savings of 9,259 ILS per year (without considering the revenue obtained through the exported energy from the PV system), and also, the green school consumed less water than the average annual water consumption by 929 m^3/year with difference percentage of 66.88%.

Table 4.14: Aqqaba Green School Performance against a Sample of School Located in Climatic Zone (I)

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	8	kWh/year	23,504	9,845	15,273	31,735	11,323	35,686	10,124
Annual Electricity Consumption Cost	8	ILS	17,247	6,988	11,405	23,089	8,602	25,893	7,175
Building Energy Index	8	kWh/m²/year	13.29	8.61	6.1	20.49	2.64	23.95	7.19
Annual Electricity Consumption Per Student	8	kWh/student/year	68	46.4	29.2	106.9	10.6	125.5	65
Area	8	M²	2,110	1,100	1,190	3,303	749	3,471	1,408
Students Number	8	Student	391	181	239	542	166	615	156
Annual Water Consumption	8	m³/year	1,389	857	672	2,105	328	2,449	460
Annual water Cost	8	ILS	7,372	7,250	1,311	13,434	0	16,343	3,278
Annual Water Consumption Per M2	8	m³/m²/year	0.76	0.56	0.27	1.24	0.04	1.48	0.33
Annual Water Consumption Per Student	8	m³/Student	3.48	1.20	2.47	4.49	1.99	4.97	2.95

4.2.4.2 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Schools in Climatic Zone (II)

Climatic Zone (II) has a hot dry in summer and mild in winter. This zone is located at dry regions. In summer the temperature could research 27°C or higher, and in winter the temperature could research around 13 °C (GEEBD, 2004). It is worth mentioning that the sample did not contain schools that lay at the zone.

4.2.4.3 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Schools in Climatic Zone (III)

Climatic Zone (III) has a climate of hot dry summer and mild winter. This zone is located at semi- dry regions of West Bank. In the summer, the temperature could reach 26°C or higher, and in winter the temperature could drop to 12°C. The cities which are located in this zone are Jenin and Tubas (GEEBD, 2004).

Based on the results summarized in Table 4.15 below, Aqqaba Green School consumed less energy than the average energy consumed by a sample of 20 schools located in Jenin and Tubas areas by 1,287 kWh/year with energy saving percentage of 11.28% and cost saving of 890.6 ILS per year (without considering the revenue obtained through the exported energy form the PV system), and also, the green school consumed more water than the average of the same schools by 74 m^3/year with difference percentage of 19.17%.

Table 4.15: Aqqaba Green School Performance against a Sample of Schools Located in Climatic Zone (III)

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	20	kWh/year	11,411	3,855	9,607	13,215	8,945	13,877	10,124
Annual Electricity Cost	20	ILS	7,165	2,396	6,044	8,287	5,632	8,698	7,175
Building Energy Index	20	kWh/m²/year	6.51	4.22	4.54	8.49	3.82	9.21	7.19
Annual Electricity Consumption Per Student	20	kWh/student/year	28.4	11.65	22.95	33.86	20.92	35.86	65
Annual Water Consumption	20	m³/year	386	349	223.5	550	163.5	610	460
Annual Water Cost	20	ILS	2,282	2,486	1,118	3,445	691	3,872	3,278
Annual Water Consumption Per M2	20	m³/m²/year	0.199	0.196	0.11	0.29	0.07	0.33	0.33
Annual Water Consumption Per Student	20	m³/student/year	0.94	0.86	0.54	1.34	0.39	1.48	2.95
Area	20	m²	2,511	1,977	1,586	3,436	1,246	3,775	1,408
Students Number	20	Student	428	132	366	490	343	512	156

4.2.4.4 Performance Measurements of Aqqaba School in Comparison to Secondary Schools Located in climatic zone (III)

The researcher was able to replicate the same analysis on the collected data of 8 secondary schools for males and females located in Jenin and Tubas cities, as they are close to Aqqaba Village, in which the green school is located. The results summarized in Table 4.16 below show that Aqqaba Green School consumed less energy than the average annual consumption of the 8 secondary schools located in Jenin and Tubas areas by 1,948 kWh/year, with energy saving percentage of 16.14% and cost savings of 1,348 ILS per year (without considering the revenue obtained through the exported energy form the PV system).

Table 4.16: Aqqaba Green School Performance against a Sample of Secondary in Climatic Zone (III)

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	8	kWh/year	12,072	2,786.82	9,742	14,402	8,624	15,520	10,124
Annual Electricity Cost	8	ILS	7,509	1,657	6,124	8,894	5,459	9,559	7,175
Building Energy Index	8	kWh/m²/year	7.72	4.02	4.35	11.08	2.74	12.7	7.19
Annual Electricity Consumption Per Student	8	kWh/student/ year	34.6	9.7	26.49	42.7	22.6	46.59	65
Area	8	m²	2,115	1,664	724	3,507	56	4,174	1,408
Students Number	8	Student	369	122	267	471	218	520	156

4.2.4.5 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Schools in Climatic Zone (IV)

Climatic Zone (IV) has a climate of warm sub-humid summer and cold winter. This zone is located at semi-humid regions of West Bank especially along the central highlands regions. The average temperature in this climatic zone could reach 16°C. The cities that are located in this zone are: Ramallah, Nablus, Hebron, Jerusalem and Bethlehem (GEEBD, 2004). According to Table 4.17 below, Aqqaba Green School consumed less energy than the baseline of annual energy consumption of climatic zone (IV) by 1,623 kWh/year with energy saving percentage of 13.8% and cost savings of 1,123 ILS per year (without considering the revenue obtained through the exported energy from the PV system), and also, the green school consumed more water than the average annual water consumption by 43 m^3/year with difference percentage of 10.32%.

Table 4.17: Aqqaba Green School Performance against a Sample of Schools Located in Climatic Zone (IV)

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	158	kWh/year	11,747	10,497	7,947	10,497	10,098	13,395	10,124
Annual Electricity Consumption Cost	158	ILS	8,769	6,525	7,743	9,794	7,415	10,122	7,175
Building Energy Index	158	kWh/m²/year	10.95	13.13	8.88	13	8.22	13.67	7.19
Annual Electricity Consumption Per Student	158	kWh/student/year	34.76	35.34	29.21	40.31	27.43	42.09	65
Area	158	M²	1,616	1,251	1,420	1,813	1,357	1,876	1,408
Students Number	158	Student	401	178	374	429	365	438	156
Annual Water Consumption	119	m³/year	417	319	358.8	474.8	340.1	493.4	460
Annual water Cost	119	ILS	2,826	2,728	2,331	3,321	2,171	3,481	3,278
Annual Water Consumption Per M2	119	m³/m²/year	0.31	0.25	0.26	0.35	0.25	0.37	0.33
Annual Water Consumption Per Student	119	m³/Student	1.07	0.83	0.92	1.22	0.87	1.27	2.95

4.2.4.6 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Schools in Climatic Zone (V)

Climatic Zone (V) has a climate of warm sub-humid summer and temperate winter. This zone is located at partially-humid regions of West Bank especially at the west of the West Bank. In summer the temperature could reach up to 25°C, and in winter the temperature could drop to 12°C. The cities that are located in this zone are: Tulkarm, Salfit and Qalqilya (GEEBD, 2004). According to Table 4.18 below, Aqqaba Green School consumed less energy than the baseline of annual energy consumption of climatic zone (V) by 515 kWh/year with energy saving percentage of 4.84% and cost savings of 357 ILS per year (without considering the revenue obtained through the exported energy from the PV system), and also, the green school consumed less water than the average annual water consumption by 454 m^3/year with difference percentage of 49.67%.

Table 4.18: Aqqaba Green School Performance against a Sample of Schools Located in Climatic Zone (V)

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	39	kWh/year	10,639	4,425	9,200	12,068	8,713	12,555	10,124
Annual Electricity Consumption Cost	39	ILS	7,674	2,913	6,730	8,619	6,409	8,939	7,175
Building Energy Index	39	kWh/m²/year	7.11	3.23	6.06	8.16	5.7	8.51	7.19
Annual Electricity Consumption Per Student	39	kWh/student/year	29.84	17.32	24.22	35.45	22.32	37.36	65
Area	39	M²	1,658	652	1,446	1,869	1,375	1,940	1,408
Students Number	39	Student	396	135	352	440	338	455	156
Annual Water Consumption	39	m³/year	914	594	721	1,106	656	1,171	460
Annual water Cost	39	ILS	3,060	2,603	2,216	3,903	1929	4,190	3,278
Annual Water Consumption Per M2	39	m³/m²/year	0.61	0.46	0.46	0.76	0.41	0.81	0.33
Annual Water Consumption Per Student	39	m³/Student	2.40	1.58	1.93	2.95	1.76	3.13	2.95

4.2.5 Performance Measurement of Aqqaba Green School in Comparison to the Performance of Other Schools Categorized Based on their Built-Up Areas

The previous analysis was made on the data of schools based on the climatic zones of where each school is located. Additional analysis was repeated on the data of schools after dividing them into three groups based on their built-up areas, which are small, medium and large schools.

According to a meeting conducted with an engineer who works at the Palestinian Ministry of Education and with another engineer who works at the Palestinian Economic Council for Development and Reconstruction (PECDAR), both argued that there is no official information about how to categorize the Palestinian schools based on their built-up areas, but they believe based on their experience and based on the data of built-up areas of the sample that the most suitable categorization of the Palestinian schools is as follows:

1- Small-Area schools: the school that has a built-up area less than 1,000-meter square.
2- Medium-Area schools: the school that has a built-up area more than 1,000-meter square and less than 2,500-meter square.
3- Large-Area schools: the school that has a built-up area more than 2,500-meter square.

4.2.5.1 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Small-Area Schools

According to Table 4.19 below, the green school consumed more energy than the average annual energy consumption of small schools by 1,152 kWh/year with different percentage of 13.84% (without considering the revenue obtained through the exported energy form the PV system), and also, Aqqaba Green School consumed much water than the average annual water consumption by 106 m^3/year with difference percentage of 30%.

Table 4.19: Aqqaba Green School Performance against a Sample of Small-Area Schools

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	58	kWh/year	8,972	7,137	7,095	10,849	6,475	11,469	10,124
Annual Electricity Consumption Cost	58	ILS	6,862	7,277	4,948	8,775	4,316	9,408	7,175
Building Energy Index	58	kWh/m²/year	18.17	18.75	13.24	23.1	11.6	24.73	7.19
Annual Electricity Consumption Per Student	58	kWh/student/year	44.28	51.9	30.63	57.92	26.12	62.43	65
Area	58	M²	616	249	551	681	529	703	1,408
Students Number	58	Student	273	163	230	316	216	330	156
Annual Water Consumption	35	m³/year	354	310	28	461	211	447	460
Annual water Cost	35	ILS	1,837	1,239	1,412	2,263	1266	2,408	3,278
Annual Water Consumption Per M2	35	m³/m²/year	0.46	0.30	0.35	0.56	0.32	0.59	0.33
Annual Water Consumption Per Student	35	m³/Student	1.39	1.92	0.73	2.05	0.50	2.28	2.95

4.2.5.2 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Medium-Area Schools

Based on the result summarized in Table 4.20 below, Aqqaba Green School consumed less energy than the baseline of annual energy consumption of medium schools by 2,265 kWh/year with energy saving percentage of 18.2% and cost savings of 1,567.38 ILS per year (without considering the revenue obtained through the exported energy from the PV system), and also, the green school consumed less water than the average annual water consumption by 141 m^3/year with difference percentage of 23.46%.

Table 4.20: Aqqaba Green School Performance against a Sample of Medium Area Schools

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	Standard deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	132	kWh/year	12,389	7,316	11,130	13,649	10,725	14,054	10,124
Annual Electricity Consumption Cost	132	ILS	9,026	5,477	8,083	9,969	7,780	10,272	7,175
Building Energy Index	132	kWh/m²/year	7.82	5.014	6.96	8.69	6.68	8.96	7.19
Annual Electricity Consumption Per Student	132	kWh/student/year	30.35	20.53	26.81	33.88	25.68	35.02	65
Area	132	M²	1,656	401	1,587	1,725	1,565	1,748	1,408
Students Number	132	Student	435	137	411	458	403	466	156
Annual Water Consumption	116	m³/year	601	515	506	695	475	726	460
Annual water Cost	116	ILS	3,116	3,310	2,552	3,770	2356	3,966	3,278
Annual Water Consumption Per M2	116	m³/m²/year	0.32	0.20	0.28	0.36	0.27	0.37	0.33
Annual Water Consumption Per Student	116	m³/Student	1.42	1.25	1.19	1.65	1.12	1.73	2.95

4.2.5.3 Performance Measurements of Aqqaba Green School in Comparison to the Actual Performance of Large-Area Schools

According to the analysis results of the data of large schools summarized in Table 4.21 below, Aqqaba Green School consumed less energy than the baseline of annual energy consumption of medium schools by 5,053 kWh/year with energy saving percentage of 33.29% and cost savings of 3,496.68 ILS per year (without considering the revenue obtained through the exported energy from the PV system), and also, the green school consumed less water than the average annual water consumption by 210 m^3/year with difference percentage of 31.34%.

Table 4.21: Aqqaba Green School Performance against a Sample of Large-Area Schools

					95 % CI		99% CI		Aqqaba School
Item	n	Unit	Mean	standard Deviation	Lower	Upper	Lower	Upper	-
Annual Electricity Consumption	35	kWh/year	15,177	7,580	12,573	17,781	11,681	18,673	10,124
Annual Electricity Consumption Cost	35	ILS	10,761	4,930	9,068	12,455	8,488	13,035	7,175
Building Energy Index	35	$kWh/m^2/year$	4.48	2.44	3.65	5.32	3.36	5.61	7.19
Annual Electricity Consumption Per Student	35	kWh/student/year	32.75	24.25	24.42	41.08	21.57	43.94	65
Area	35	M^2	3,793	1,831	3,164	4,422	2,948	4,637	1,408
Students Number	35	Student	497	156	443	550	425	569	156
Annual Water Consumption	32	$m^3/year$	670	568	465	875	394	945	460
Annual water Cost	32	ILS	3,943	3,520	2,674	5,212	2,235	5,650	3,278
Annual Water Consumption Per M2	32	$m^3/m^2/year$	0.18	0.16	0.12	0.23	0.10	0.25	0.33
Annual Water Consumption Per Student	32	$m^3/Student$	1.47	1.28	1.01	1.93	0.85	2.09	2.95

4.3 Actual Performance Compared to Predicted Performance in the Design Phase

According to a report prepared by Baba et.al (2015), Aqqaba Green School was designed as a green school with high energy efficiency techniques.

According to the report, Design Builder Software version 2.2.5 was used to analyze and simulate the performance of the green school. The simulation process started by drawing a model for the building of Aqqaba Green School, then added the weather data of an area near Ramallah City to the program because the climate of that area is similar to the climate of Aqqaba Village. Also, the simulation process was conducted based on the assumption that the green school will be used for 8 hours/day, 5 days/week for a period of nine months, starting in September and ending in June, with defining two main holidays, which are Eid Al-Fitr and Eid Al-Adha (Baba et.al (2015).

The final results of the predicted simulation showed that the required heating load on average is around 8.5 kWh/m²/year, which is very low due to solar gains, efficient insulation and internal gains. Also, the results showed that the required cooling load is around 53 kWh/m²/year, noting that the green school will not be used on June, July and August (which are the months with the highest levels of heat). In total Aqqaba Green School is predicted to consume energy by around 61 kWh/m²/year excluding the energy consumption of lighting units and other compliances (Baba et.al, 2015).

Furthermore, Baba et.al (2015) argued that the efficient shading and insulation used in the green school played a vital role in reducing cooling gains compared with other similar Palestinian schools.

Based on the collected data of the actual energy consumption of Aqqaba Green School, the actual annual energy consumption of this green school is 7.19 kWh/m²/year, which include the energy consumption of lighting units and other appliances, which is much less than the predicted value in the design by 88.2%, so the actual performance of Aqqaba Green School is significantly lower than the predicted performance, which is considered as a positive assessment point for the school.

In addition to the data obtained from the report, the researcher conducted a meeting with the designer office which was responsible for the thermal simulation of Aqqaba Green School. In their response to our inquiry about the reasons that resulted in the reduction in energy consumption, they said that they believe that the effective shading, good orientation of school building, efficient insulation, dependency on natural lighting, limited number of air-conditioning units and replacing air-conditioning units with fans are all factors that play a major rule in reducing energy consumption. Table 4.22 below summarizes the difference between the actual and the assumed conditions of the green school.

Table 4.22: Comparison between the Assumed and the Actual Status of Aqqaba Green School

Item	Assumed Conditions	Actual Conditions
Energy Intensity	*61 kWh/m²/year	7.19 kWh/m²/year
Annual Energy Consumption	*85,888 kWh/year	10,124 kWh/year
Density of Occupants	1 student/1.4m²	1 student/2.24m²
Weather Conditions	Area near Ramallah City	Aqqaba Village
Number of Students	250 Students	156 Students
Heating and Cooling Conditions	The school will be totally heated and cooled by air conditioning units	Air conditioning units in classrooms are replaced by fans

*Predicted Consumption

To summarize this chapter, which is considered the main part of the research, the researcher started by identifying the types of data needed to empirically answer the research questions. These types of data were divided into three categories: the anticipated and the actual energy consumption levels for Aqqaba Green School, the monthly energy and water consumption reports for other Palestinian schools, and the built-up areas and the number of students for each school included in the sample. Furthermore, the chapter summarized the different stages of data analysis used to proof the researcher's point of view related to the reduction in energy and water consumption in Aqqaba Green School compared to other schools in the West Bank. The data analysis started by calculating the annual consumption of energy and water of each school included in the sample. The next stage included the development of the needed baseline of consumption through defining and excluding the outliers. Finally, the chapter ended with an assessment of the actual performance of the green through comparing the actual energy and water consumption levels of Aqqaba Green School with the developed baselines on one hand, and with the predicted levels of consumption on the other.

The next chapter presents the conclusion of this research and provides a summary for the research questions and objectives. In addition, the following chapter provides recommendations for future research. The next chapter also sheds light on the limitations of the findings.

Chapter Five

Conclusion and Recommendations

Chapter Five

Conclusion and Recommendations

The main aim of this study was to assess the actual energy performance of a green building in Palestine, which is Aqqaba Green School, by comparing its performance with the baseline developed by the researcher based on the annual energy and water consumption for a sample consists of 205 non-green schools in West Bank in Palestine. Also, this research assessed the actual energy consumption of Aqqaba School by comparing its actual consumption with the predicted consumption in the design phase.

5.1 Summary of Findings

- The baseline of the annual energy consumption of the Palestinian non-green schools in the sample is 10,639 kWh/year, while the annual electricity consumption of Aqqaba Green School is 10,124 kWh/year, so Aqqaba Green School consumed less energy than the baseline by 515 kWh/year with saving percentage of 4.84%. The annual energy saving corresponds to a cost savings of 356.40 ILS/year without taking into account the exported energy to the grid.
- Aqqaba Green School is supplied with a grid connected PV system with a capacity of 15 kWp, and in its first year of operation, the green school has exported around 14,550 kWh/year of energy to the grid and also, the green has consumed around 10,124 kWh/year. This

yields 4,426 kWh/year as surplus of energy. Therefore, Aqqaba Green School can be classified as energy plus building.

- By taking into account the exported energy to the grid, it is found that the revenue obtained from the exported energy to the grid offsets the annual energy cost and secures an annual income of 2,297 ILS/year.
- Without considering the generated energy in the green school, the annual electricity consumption cost of Aqqaba green school is 7,175 ILS/year, which is less than the average annual consumption cost of non-green schools by 573 ILS with difference percentage of 7.40%.
- The baseline Building Energy Index (BEI) of non-green schools is 9.56 kWh/m²/year, while the Building Energy Index (BEI) of Aqqaba Green School is 7.19 kWh/m²/year which is less than the established baseline by 24.79%, and that is because the built-up area of the green school is less the mean value of areas of schools in the sample.
- The baseline of the annual electricity consumption per student of non-green schools is 31.39 kWh/Student/year, while the annual electricity consumption of the green school is 65 kWh/Student/year which is higher than the baseline by of 107%, and that is because the number of student of the green school is less the mean value of student's number of schools in the sample.
- The baseline of the annual water consumption of non-green schools in the sample schools is 450 m³, while the annual water consumption of Aqqaba Green School is 460 m³, so Aqqaba Green School consumed 2.2 % more water than the baseline.

- The baseline of the annual water consumption per student of non-green schools was 1.25 m^3/student/year, while the annual water consumption of the green school was 2.95 m^3/student/year with difference percentage of 136%, that is due to the difference between the number of students at the green school and the mean of number of students of schools in the sample.
- The explanation that the energy and water consumption of Aqqaba Green School was close to the developed baselines is due to using the school for tawjihi exams, summer camps, the available green area in the school and finally, hosting nighty activities.
- Aqqaba Green School was designed to consume energy of 61 kWh/m^2/year, which is much higher than the actual energy consumption by 88.2%, so the actual performance is much lower than the expected performance in the design phase of the School.

5.2 Research Limitations

Although this research has met its aim, and the research methodology was carefully designed, due to time and budget constraints, the following limitations are associated with the results:

1. The developed baseline cannot be statistically generalized for the whole school population in Palestine. This is because the sample of the research is not a statistically representative random sample.

2. Although the data can be classified as time series data, but it covers a period of one year only which is the year 2016 for the sample and the years 2016 and 2017 for the case study.

5.3 Recommendations

In light of the results of this research, the researcher recommends the following:

1. To enlarge the scope of the research by studying and comparing the thermal comfort of Aqqaba Green School with the thermal comfort of non-green schools in Palestine.
2. To increase the sample size by collecting data of all non-green schools in Palestine.
3. To increase the study interval by including time series data for more than one years.
4. To assess the revenue obtained from energy generation from life cycle perspective.
5. To install PV system on each governmental school, so the Ministry could gain the economic benefits obtained from installing such systems.
6. To develop a database contains weather data files of the main cities of the West Bank, so designers of green buildings could use in the simulation process of green buildings.
7. To officially categorize the Palestinian schools based on their built-up areas to small, medium and large schools.

5.4 Future Work

Since the aim of this study is to compare the actual performance of Aqqaba Green School with the baseline of non-green schools in Palestine, the following future work is recommended:

1- To enhance this research by collecting the data for the population which consists of 1,784 non-green schools in Palestine in order to develop more statistically representative baseline.

2- To apply regression analysis on the collected data in order to see the relationship exists between the annual energy consumption and the built-up area of schools and also, to identify the main factors that have the major effect on the annual energy consumption.

3- To assess the thermal comfort and indoor air quality of Aqqaba Green School against the thermal comfort of non-green schools in Palestine.

To conclude what was achieved through this thesis, it is worth to remind the readers with the research questions and the objectives of this study and how these objectives were achieved. The objectives of thesis were derived from the set of the research questions; the first objective of this research was to compare between the actual performance of Aqqaba Green School with its anticipated performance that resulted from the simulation. This objective was achieved through obtaining data related to the actual energy consumption of Aqqaba Green School, then, comparing this data to the predicted energy consumption level in order to define the difference between these two values. The second objective was to compare the actual energy and water consumption of Aqqaba Green School with the baseline of Palestinian schools. This objective was achieved by collecting actual data related to the monthly energy and water consumption levels for a sample of Palestinian schools which were used to develop the needed baseline, then, the actual performance of Aqqaba School was compared to the developed baseline. The third and final objective in this research was to quantify the cost savings in energy and water consumption of Aqqaba Green School compared to the baseline. This objective was accomplished by calculating the difference between the actual consumption of Aqqaba Green School and the value of the baseline, then, the difference in consumption was converted to cost.

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Appendices

Appendix I: Confidence Intervals Using 1-Sample-t for Annual Energy Consumption and Cost

One-Sample T: C1

Variable	N	Mean	StDev	SE Mean	95% CI
C1	205	10639	5534	387	(9876, 11401)

One-Sample T: C1

Variable	N	Mean	StDev	SE Mean	99% CI
C1	205	10639	5534	387	(9634, 11644)

One-Sample T: C2

Variable	N	Mean	StDev	SE Mean	99% CI
C2	205	7748	4141	289	(6996, 8500)

One-Sample T: C2

Variable	N	Mean	StDev	SE Mean	95% CI
C2	205	7748	4141	289	(7178, 8318)

Figure_Apx I-1: Confidence Intervals for the data of the annual energy consumption and cost repectively

Appendix II: Confidence Intervals Using 1-Sample-t for the Data of Energy Consumption Per m² and Per Student

One-Sample T: C5

Variable	N	Mean	StDev	SE Mean	95% CI
C5	205	9.562	10.526	0.735	(8.112, 11.011)

One-Sample T: C5

Variable	N	Mean	StDev	SE Mean	99% CI
C5	205	9.562	10.526	0.735	(7.650, 11.473)

One-Sample T: C6

Variable	N	Mean	StDev	SE Mean	99% CI
C6	205	31.39	26.25	1.83	(26.62, 36.16)

One-Sample T: C6

Variable	N	Mean	StDev	SE Mean	95% CI
C6	205	31.39	26.25	1.83	(27.78, 35.00)

Figure_Apx II-1: Data analysis for BEI per meter square and per student respectively

Appendix III: Confidence Intervals Using 1-Sample t for the Data of Annual Water Consumption and Cost

One-Sample T: awc

Variable	N	Mean	StDev	SE Mean	95% CI
awc	166	449.6	286.8	22.3	(405.6, 493.5)

One-Sample T: awc

Variable	N	Mean	StDev	SE Mean	99% CI
awc	166	449.6	286.8	22.3	(391.6, 507.6)

One-Sample T: twc

Variable	N	Mean	StDev	SE Mean	99% CI
twc	166	2388	1660	129	(2053, 2724)

One-Sample T: twc

Variable	N	Mean	StDev	SE Mean	95% CI
twc	166	2388	1660	129	(2134, 2643)

Figure_Apx III-1: Results of confidence intervals for the data of annual water consumption and cost respectively

Appendix IV: Confidence Intervals Using 1-Sample t for the Data of Annual Water Usage Intensity Per m² and Per Student

One-Sample T: cmpms

Variable	N	Mean	StDev	SE Mean	95% CI
cmpms	166	0.3255	0.2589	0.0201	(0.2858, 0.3652)

One-Sample T: cmpms

Variable	N	Mean	StDev	SE Mean	99% CI
cmpms	166	0.3255	0.2589	0.0201	(0.2731, 0.3779)

One-Sample T: cmps

Variable	N	Mean	StDev	SE Mean	99% CI
cmps	166	1.2473	0.9268	0.0719	(1.0599, 1.4348)

One-Sample T: cmps

Variable	N	Mean	StDev	SE Mean	95% CI
cmps	166	1.2473	0.9268	0.0719	(1.1053, 1.3893)

Figure_Apx IV-1: Confidence interval results for the data of the annual water usage per meter square and per student respectively

جامعة النجاح الوطنية
كلية الدراسات العليا

تقييم الأداء الفعلي للمباني الخضراء في فلسطين: دراسة حالة

إعداد
حاتم غالب حسن الحضيري

إشراف
د. لؤي دويكات

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الادارة الهندسية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين
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الملخص

تشير الادلة العلمية إلى أن الأداء الفعلي للمباني غالبا لا يطابق الاداء المتوقع من ناحية استهلاك هذه المباني للكهرباء والمياه، حيث تعتبر هذه القضية من إحدى القضايا التي تناقش باهتمام في مجتمع البحث العلمي. يهدف هذا البحث إلى تقييم الاداء الاقتصادي الفعلي لأول مدرسة خضراء في فلسطين، مدرسة عقابا الخضراء، من ناحية استهلاك المدرسة للكهرباء والمياه، ومن ثم تحديد كمية التوفير مقارنة باستهلاك المدارس الاخرى في فلسطين. وكما يهدف هذا البحث إلى البحث عن مدى مطابقة الاداء الفعلي للمدرسة الخضراء للاداء المتوقع في مرحلة التصميم. ولمقارنة أداء مدرسة عقابا الخضراء مع أداء المدارس الاخرى، تم جمع بيانات لاستهلاك الكهرباء والمياه لعينة حجمها 205 مدرسة فلسطينية لعام 2016. ونتيجة للتحليل الاحصائي لبيانات الكهرباء، وجد أن معدل الاستهلاك السنوي من الكهرباء لمدارس العينة هو 10,639 كيلو واط / السنة بما يعدل معدل استهلاك بمقدار 9.56 كيلو واط / متر^2 / السنة للمتر المربع ، بينما بلغ استهلاك المدرسة الخضراء من الكهرباء لعام 2016 هو 10,124 كيلو واط / السنة والذي يعادل استهلاك مقداره 7.19 كيلو واط / متر^2 / السنة للمتر المربع . وتبعا للبيانات المتعلقة بانتاج الخلايا الشمسية التابعة للمدرسة لأول سنة تشغيلية، وجد أن هذه الخلايا الشمسية قامت بتوليد طاقة أكثر من استهلاك المدرسة بمقدار 4,426 كيلو واط / السنة وبعائد مقداره 2,297 شيكل / السنة. وتبعا لنتيجة التحليل الاحصائي لبيانات المياه، وجد ان معدل استهلاك المياه السنوي لمدارس العينة 450 متر مكعب / السنة بما يعادل معدل استهلاك مقداره 1.25 متر مكعب / طالب / السنة للطالب الواحد، بينما بلغ استهلاك مدرسة عقابا الخضراء من المياه 460 متر مكعب / السنة والذي يعادل استهلاك بمقدار 2.95 متر مكعب / طالب / السنة للطالب الواحد. وعند مقارنة

الاداء الفعلي لمدرســـة عقابا الخضـــراء مع اداءها المتوقع ، وجد أن الاداء الفعلي للمدرســـة بلغ 7.19 كيلو واط / متر² / السنة في اول سنة تشغيلية للمدرسة والذي يشكل ما نسبته 11.79% من الاداء المتوقع في مرحلة التصميم والبالغ 61 كيلو واط / متر² / السنة.