THE PRESENCE OF BIOMIMICRY PRINCIPLES IN MALAYSIAN GREEN BUILDING RATING TOOLS

BY

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ABSTRACT

Concerns about climate change and global warming have initiated consciousness of environmental approaches in the planning and development of the built environment. Among them are the green building rating systems (LEED, BREEAM, GBI, etc.) as advocated by many countries to create more sustainable and responsible buildings and developments that are less harmful to the environment. Although good and novel, this thesis looks at the integration of biomimicry into those rating systems for achieving a higher level of sustainability upon the natural environment. The study aims to assess the presence of Biomimicry Life's Principles (BLP) and the extent of their presence in one of green building rating tools, which is the Green Building Index (GBI) Malaysia. The study utilized the content analysis method to explore the synergy between the existing green building rating systems and the biomimicry frameworks for achieving high level of sustainable development. Such bio-integration is recommended to improve the development of effective, regionally sensitive and energy efficient built environment for creating better social equalities. The results demonstrated that most of the Biomimicry Life's Principles (13 out of 20) existed within the GBI but in a very low extent, the presence percentage is 4.7%. Only two of the BLP were fully fulfilled meaning that all of their sub-principles existed in the GBI. The BLP are "Be Resource Efficient (Energy and Materials)" and "Adapt to Changing Conditions". Each main principle of BLP existed in some parts of the GBI except that "Be Resource Efficient (Materials & Energy)" appeared in all of GBI parts but with different levels of fulfillment. The Energy Efficiency (EE) part of the GBI had the highest numbers of BLP (35% or 7 out of 20 sub-principles). It is recommended that the further studies should be about how to apply or employ the missing principles in the GBI to enhance it further. It is also recommended that more studies are required on ways to increase the extent of using Biomimicry strategies into existing criteria in the GBI for a more holistic rating tool.

خلاصة البحث

إنّ المخاوف بشأن التغير المناخي والاحتباس الحراري، قد أحدثت وعيًا بالمنهج البيئي لتخطيط وتطوير البيئة العمرانية. ومن بينها أنظمة تصنيف المباني الخضراء (LEED، BREEAM، GBI، إلخ)، مما دعا العديد من الدول لإنشاء مبانٍ أكثر استدامة ومسؤولية، وأقل ضررًا للبيئة. على الرغم من الغريب الجديد، فإنّ هذا البحث يتطلع إلى دمج محاكاة الطبيعة في تلك النُّظم لتحقيق مستوى أعلى من الاستدامة للبيئة الطبيعية. وتهدف هذه الدراسة إلى تقييم تحقق مبادئ محاكاة الطبيعة (BLP) ومدى وجودها في واحدة من الأدوات الخضراء لتصنيف المباني، وهو مؤشر ماليزيا للأبنية الخضراء .(GBI) استخدمت الدراسة أسلوب تحليل المحتوى لاستكشاف التآزر بين أنظمة تصنيف المباني الخضراء القائمة، وأُطر محاكاة الطبيعة لتحقيق مستوى عالٍ من التنمية المستدامة. ويُوصى بهذا التكامل الحيوي لتحسين وتطوير مبانٍ ذات كفاءة بيئيّة فعالة وحساسة إقليميًّا؛ بُنيت لتحقيق مساواةٍ اجتماعيّةٍ أفضل. وأظهرت النتائج أنّ معظم مبادئ محاكاة الطبيعة (13 من 20) تحققت لدى GBI ، ولكنها بدرجة قليلة جدًّا، ونسبة الحضور هي 4.7٪. اثنين من BLP ، فقط تمَّ الوفاء بها بشكل كامل وهي "كون كفاءة (الطاقة والمواد) متكيّفة مع الظروف المتغيرة". وتحققت كل المبادئ الرئيسة لـBLP في بعض أجزاء من GBI ، إلا أنّ "كون كفاءة (الطاقة والمواد)" ظهرت في جميع أجزاء GBI ، بمستويات مختلفة. وكان لكفاءة الطاقة (EE) التي هي جزء من GBI أكبر عدد من (35%) BLP أو 7 من أصل 20 مبدأً فرعيًّا. إنه من المستحسن إجراء المزيد مِن الدراسات التي ينبغي أنْ تكون حول كيفية تطبيق أو توظيف المبادئ المفقودة في GBI، لتحسين ذلك أخيرًا، ويُوصّى أيضًا بأنّ هناك حاجة لمزيد من الدراسات حول سبل زيادة مدى استخدام استراتيجيات محاكاة الطبيعة في المعايير القائمة بالفعل في GBI من أجل الحصول على أداة تقييم أكثر شمولية.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation. It is also fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Building Services Engineering.

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Noor Aziah Mohd Ariffin
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation. It is also fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Building Services Engineering.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Salwa Gad

Signature ..... Date .....

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LIST OF ABBREVIATIONS

BLP	Biomimicry Life's Principles
GBI	Green Building Index
EE	Energy Efficiency
EQ	Indoor Air Quality
SM	Sustainable Site Planning and Management
MR	Materials and Resources
WE	Water Efficiency
IN	Innovation

CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

The substantial advances in building assessment or energy rating tools over the last two decades revealed that they were able to lower the negative impact of man-made environments on the natural environment. However, in order to further enhance the sustainability goals, these tools need to be strengthened. The synergy of biomimicry principles in these rating systems is expected to reduce further the negative impact of building on the natural environment, thus making them better places to live in a better environment and social equalities. Such bio-integration will serve to improve the development of more regionally sensitive and energy efficient built environment. Therefore, this paper explore the presence of Biomimicry Life's Principles in Malaysian Green Building Index (GBI) in order to visualize the future development and enhancement that could be taken into account in the future version of this rating system.

The study explores the presence of Biomimicry Life's Principles in Malaysian's GBI. This chapter introduces this study including the problem statement, the research questions, aim and objective, and the theoretical framework.

1.2 BACKGROUND

Nowadays, global warming and climate changes are becoming major concerns due to their serious effects on humanity from all aspects. How people build and inhabit urban areas is recognized as a significant contributor to many of the drivers of global environmental degradation. This includes loss of biodiversity, climate change,

excessive use of natural resources and reductions of ecosystem's ability to provide services that humans rely on (Rees 1999; McDonough and Braungart, 2002; Zari 2015). For example, the Intergovernmental Panel on Climate Change (IPCC) in their 2014 reports submitted that buildings are responsible for 32 % of total global energy use, 19 % of energy-related GHG emissions, 51 % of world electricity consumption, and around one-third of black carbon emissions (IPCC, 2014).

Realizing this, sustainable development all over the world are evolving and causing significant changes in the building delivery systems (Kibert, 2012; Bhamra & Lofthouse, 2007). There are several definitions of sustainable development and one of them is defined by Brundtland Commission in 1987 as the "development that meets the needs of present without compromising the ability of future generation" (Wheleer, 2013). Consequently, many sustainable design approaches have been developed over the past three decades such as green building design, eco-design, and sustainable construction (Gamage and Hyde, 2012; Kibert, 2012; Birkeland, 2002). These approaches express specific techniques that aim to apply sustainability principles in the built environment. The goal is to improve human well-being by stimulating the efficient use of resources and energy, and the development of techniques for recycling and waste reduction. The overall objective of sustainable design is to reduce the negative impact of buildings on the natural environment (Gamage and Hyde, 2012; Kibert, 2012).

High-performance green building, or simply called green building, is one of the outcomes of applying sustainable approaches to creating a responsible built environment. Over the past twenty years, green building has developed to become the most significant trend in the building industry (Kibert, 2012). One of the results of the green building movement, has been the emergence of the green building rating systems such as Green Building Index (GBI), Leadership in Energy & Environmental Design

(LEED), and Building Research Establishment Environmental Assessment Methodology (BREEAM). These systems provide grading systems and detailed criteria to evaluate buildings and guide designers toward achieving sustainable building. These rating systems represent a way to certify that the building is indeed green.

On the other hand, in the last decade, there is an evolving of new approaches that are beginning to explore nature and trying to understand its dynamic integration to achieve a higher level of sustainability. Nature provides many lessons for human to learn about how to achieve sustainability. These approaches include construction ecology, ecological design, regenerative design, biophilia, biomimetic, and Biomimicry. These terms describe the overall scientific and philosophical concepts that apply to the required paradigm shift towards sustainability. These disciplines try to elicit nature principles based on the idea of biological coherence of environmental operating system (Gamage & Hyde, 2012).

Biomimicry is gaining importance in sustainable building design (Zari, 2007). According to Hanafi & Naguib (2013), Biomimicry provides a lot of inspiration lessons that help in producing more effective, regionally sensitive and energy efficient buildings. Several means have been developed to help in applying biomimicry approach, such as a framework of life's principles, and design approaches. Through a clear understanding of natural processes and their interactions with human needs, designers can create buildings that are functionally productive and regenerative by design in order to achieve a high level of sustainability (John, et al., 2005; Zari, 2015).

Therefore, it becomes imperative to have a synergy between the existing green building rating systems and the biomimicry frameworks. Such combination will serve to improve the design, construction and operation of buildings thereby, reducing the detrimental effects often associated with the built environment.

1.3 PROBLEM STATEMENT

Concerns about climate change and global warming have initiated a consciousness of environmentally friendly approaches. One of these approaches is green building design that aim to improve human well-being by motivating the efficient use of resources and energy, and developing techniques for recycling or by reducing waste. The aim of green building assessment tools is to lower the building's negative impact on the natural environment. However, these tools need to be enhanced, in order to reach determined sustainable goals.

Recently, many disciplines are starting to explore nature and are attempting to understand its bio-integration in order to allow for the establishment of sustainable products, processes and systems (Reap, 2009). One of these disciplines is Biomimicry, which is gaining importance as a widespread movement in design for sustainable development (Benyus, 1997, Zari, 2007). According to Hanafi & Naguib (2013), Biomimicry provides numerous inspiration lessons, and it offers examples of how "designing with nature" can help in designing sustainable or green buildings.

It becomes clear that natural or ecological principles are capable of providing many benefits to green building design and increasing the efficiency, sustainability and the environmental performance of these buildings. However, limited evidence exists on addressing the extent of application of ecological or natural principles in green building design.

It is against this background that this dissertation explores the implementation of the principles of biomimicry in green building design activities, especially in green buildings rating system used. Thus for, there is no attempt to investigate the integration of Biomimicry's Life Principles (BLP) in the Green Building Index (GBI) system

employed in Malaysia, this research analyzes GBI in terms of the presence and the extent of the application of BLP in order to visualize the possible future development of the built environment.

1.4 RESEARCH AIM AND OBJECTIVES

1.4.1 Aim of the study

The primary aim of this research is to assess the potential of the integration of Biomimicry Life's Principles (BLP) to enhance the existing green building energy rating systems, the Malaysian Green Building Index (GBI).

1.4.2 Objectives

To achieve the stated aim, the research has the following objectives:

1. To explore biomimicry and its integration with GBI in developing the built environment.
2. To analyze the presence and extent of usage of BLP in the existing green building rating systems.
3. To recommend the integration of BLP into the current green building rating systems for better sustainability.

1.5 RESEARCH QUESTIONS

The key research questions to be answered by the research are:

1. What is biomimicry and how it integrated in the built environment?
2. Are the principles of biomimicry present in the existing green building rating systems and to what extent?

3. Can biomimicry be integrated into the existing green building rating systems for better sustainability of the environment?

1.6 OVERVIEW OF RESEARCH METHODOLOGY

1.6.1 Methodology

In order to achieve the stated aim and the subsequent questions posed, the following steps formed the methods used in this study:

1. A literature review of biomimicry, to explore the principles related to the creation of a more holistic built environment that takes into consideration the importance of integration of the natural principles in built environment.
2. Content analysis of GBI Malaysia used to investigate the presence of the biomimicry principles and the extent of their presence in the existing ratings.
3. The findings would form a basis for the recommendation of improving the present rating tools.

1.7 THEORETICAL FRAMEWORK

The theoretical framework is illustrated in Figure 1.1. It shows that in response to the need to address sustainability in built environment, two approaches were developed. One is based on natural principles (i.e. BLP), and another one is based on sustainable development principles (i.e. GBI). The goal is to have a synergic relationship between these two approaches in order to achieve a high level of sustainability.

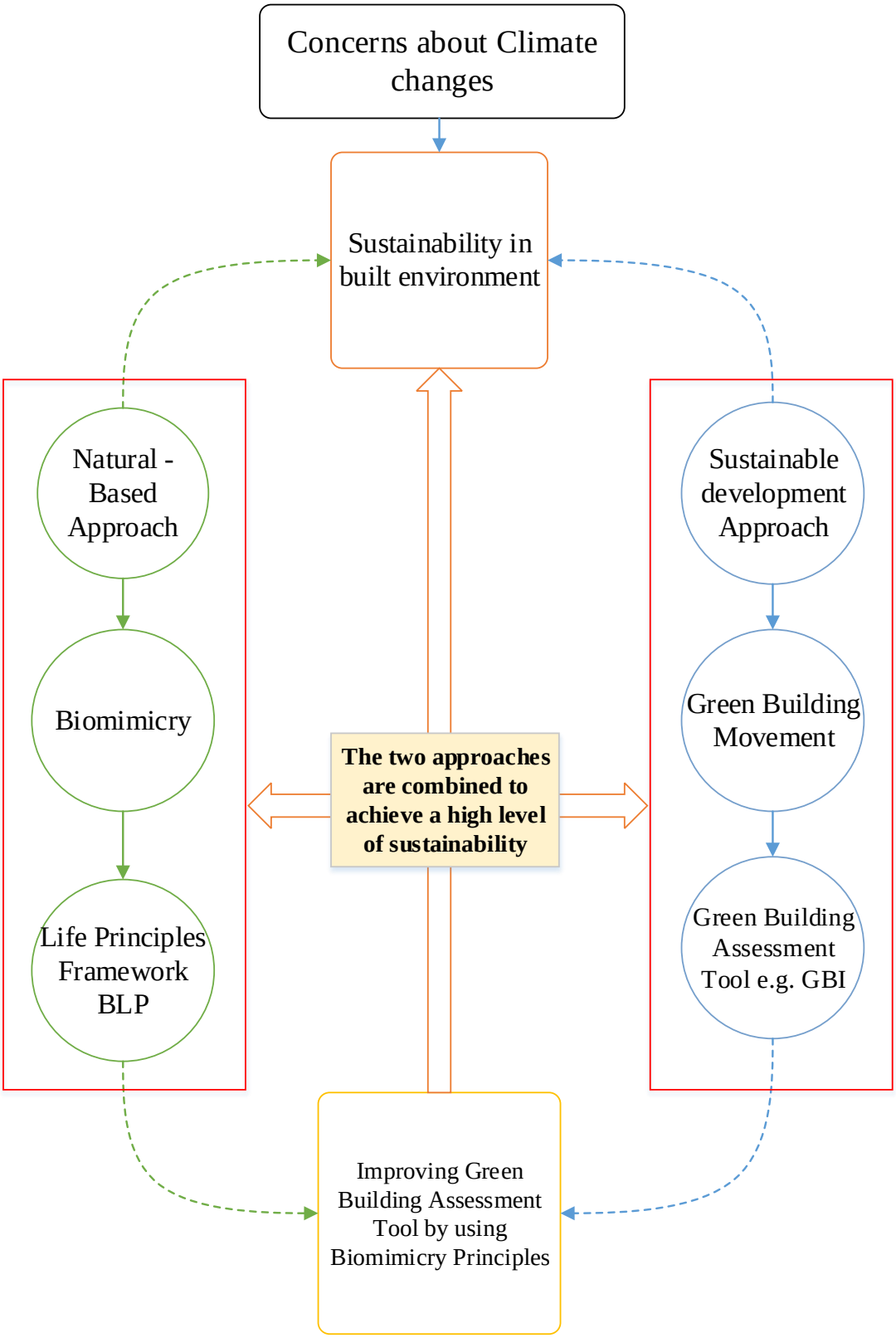

Figure 1.1: Theoretical Framework

1.8 SIGNIFICANCE OF THE STUDY

The substantial advances in building assessment tools over the last decade already revealed that they were able to lower the negative impact of buildings on the natural environment. However, in order to reach determined climate goals, these tools need to be strengthened. The synergy of Biomimicry Life's Principles in these rating systems could reduce the negative impact of building on the natural environment.

1.9 SCOPE

The scope of this research is to use Biomimicry Life's Principles (BLP) as a tool for analyzing existing green building rating tools. The document that is analyzed in this research is Malaysia's Green Building Index Design Reference Guide for Non-Residential New Construction (NRNC) Version 1.05, September 2011. The focus will be on the **Assessment Criteria** section of this document. For the biomimicry principles, Life's Principles framework by *Biomimicry 3.8* (2013) in its design lens is used (Figure 2.14).

1.10 THESIS STRUCTURE

This dissertation is an attempt to establish a link between green building rating system and biomimicry by using an exploratory and analytical approach. In Chapter two, biomimicry and its contribution to sustainable architecture were explored. From this literature review, a framework of life's principles was explained which was used to analyze the GBI. Then, in Chapter three, green building rating system was addressed and explored. Focus was given to GBI since it is the focus of this research, and it was analyzed by using content analysis method in order to evaluate the presence of biomimicry principles. Chapter four discusses the methodology used and the stages

through which the research conducted. The analysis process and the results are presented in Chapter five. Finally, the results are discussed in Chapter Six and the conclusion drawn.

CHAPTER TWO

BIOMIMICRY

2.1 INTRODUCTION

This study explores the introduction of BLP into green building rating systems. Therefore, it is essential that the concepts of Biomimicry is understood well. This chapter provides an overview of Biomimicry and its contribution to sustainability and architecture. Moreover, Biomimicry lenses and elements are explained including design approaches, levels, and life's principles.

2.2 BACKGROUND

Nature is well organized and in harmony. Throughout the centuries, humans struggled to understand their world by observing nature and learning from it, and then using the lessons learned appropriately. However, 'The Industrial Revolution' or ('The Fossil Fuel Age') redirect humans from the creativity they had before in common with the advanced solutions from nature. Many lessons from nature that have been utilized in vernacular architecture were therefore abandoned. The availability and convenience of fossil fuels have resulted in extreme inefficiency (Pawlyn, 2011). Nature provides models from which human can study (Van der Ryn & Cowan, 2013; Pawlyn, 2011).

Nature can provide an ecological model to measure if a building is sustainable or not. Understanding the natural way to achieve sustainability helps in establishing performance standards that could help in assessing the built environment (Gamage and Hyde, 2012: Zari, 2014, 2015). Also, studying the methods that biotic systems utilize to reach their sustainable state could allow the establishment of sustainable processes

and systems (Reap, 2009). This understanding generates the ability to create a built environment that is significantly sustainable.

Many recent approaches to sustainable architecture were starting to explore lessons from nature, and usually they are called bio-inspired approaches such as biomimicry, biomimetic, or ecomimicry. Naturally inspired design approaches are based on analogies with the architecture and biology (Pawlyn, 2011). Biomimicry is an emerging discipline that introduces a way of not to extract from nature, but to learn from it. It is a conscious imitation of "nature's genius" (Benyus, 1997). Biomimicry is the "technology of biology" (Baumeister, 2012).

2.3 HISTORICAL OVERVIEW

The term *biomimicry* emerged as early as 1982 and it was made famous after Janine Benyus wrote her book *Biomimicry: Innovation Inspired by Nature* in 1997, Benyus defined biomimicry as "new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems". In addition to Benyus, others individuals like Steven Vogel (Biology Professor), Julian Vincent (Biomimetics Professor) and others, all of them have written broadly on this subject (Pawlyn, 2011). Julian Vincent defines biomimicry as "the abstraction of good design from nature" (Pawlyn, 2011). Vogel in his book *"Cats' Paws and Catapults: Mechanical Worlds of Nature and People"* (1998) examines how living things work and grow and he showed the differences between natural technology and the man-made technology. He demonstrated how a human can enrich their understanding of what is done and have been done by looking at natural technology.

In 1998, Benyus and Dayna Baumeister formed the Biomimicry Guild (a consulting company) to galvanize the spread of this movement. This Institute provides