The Study of Sustainable Architectural Design in Thailand

การศึกษาแนวทางการออกแบบสถาปัตยกรรมยั่งยืนในประเทศไทย

Sirimas Hengrasmee
สิริมาส เฮงรัศมี

The Study of Sustainable Architectural Design in Thailand
การศึกษาแนวทางการออกแบบสถาปัตยกรรมยั่งยืนในประเทศไทย

Sirimas Hengrasmee
สิริมาส เฮงรัศมี

Faculty of Architecture, Naresuan University
คณะสถาปัตยกรรมศาสตร์ มหาวิทยาลัยนเรศวร

Abstract

Based on the results of the research in 2004, this article aims to suggest a guideline to develop an appropriate approach of sustainable architectural design in Thailand. Rather than creating a checklist, this article points out the areas that are commonly ignored by the current approaches of Thai sustainable architecture. The analysis is based upon literature review of books, articles, and reports covering issues related to sustainable development and sustainable, ecological, and green architecture. The progress of sustainable development and sustainable architectural design at national and international levels are reviewed and analyzed with an intention to compare sustainable architectural design in Thailand with a concept of sustainable development and the international theory of sustainable design. Three images that characterize different approaches of sustainable architectural design in Thailand are building technology/energy conservation, culture/vernacular architecture, and community and urban planning. According to the study, the approaches of Thai sustainable design are limited and cannot capture the whole idea of the international concerns toward sustainability. In order to make sustainable architectural design in Thailand more comparable to the international approach as well as suitable for Thai context and the country's policy, such as the "Sufficiency Economy" concept, sustainable architectural design in Thailand should be more developed and integrate those international concerns with Thailand's approaches.

บทคัดย่อ

บทความฉบับนี้อ้างอิงมาจากผลงานวิจัยที่จัดทำขึ้นเมื่อปี พ.ศ. 2547 เนื้อหาของบทความมีวัตถุประสงค์เพื่อเสนอแนะแนวทางการพัฒนาแนวความคิดเกี่ยวกับการออกแบบสถาปัตยกรรมยั่งยืนในประเทศไทย โดยมีจุดมุ่งหมายหลักเพื่อนำเสนอประเด็นที่ไม่ได้รับการเอาใจใส่จากแนวทางการพัฒนาในปัจจุบัน วิธีการศึกษาเป็นการศึกษาในลักษณะของการทบทวนวรรณกรรมที่เกี่ยวข้อง ทั้งในรูปแบบของหนังสือ บทความ และรายงานต่าง ๆ ที่มีการกล่าวถึงเรื่องของการพัฒนาอย่างยั่งยืน สถาปัตยกรรมยั่งยืน นิเวศน์สถาปัตยกรรม และสถาปัตยกรรมสีเขียว เป็นต้น ทั้งนี้ พัฒนาการของการพัฒนาอย่างยั่งยืนและแนวความคิดสถาปัตยกรรมยั่งยืนในระดับประเทศและระดับสากลได้ถูกพิจารณาเพื่อนำมาเปรียบเทียบสถานการณ์ในปัจจุบัน

จากการศึกษาพัฒนาการทางแนวความคิดสถาปัตยกรรมยั่งยืนในประเทศไทย พบภาพลักษณ์หลัก ๆ ที่มีมุมมองต่อแนวความคิดสถาปัตยกรรมยั่งยืนที่แตกต่างกัน โดยสามารถแบ่งได้เป็นสามแนวทางคือ ภาพลักษณ์เชิงเทคโนโลยีและการประหยัด/อนุรักษ์พลังงาน ภาพลักษณ์เชิงวัฒนธรรม/สถาปัตยกรรมพื้นถิ่น และภาพลักษณ์เชิงชุมชนและผังเมือง ทั้งนี้ จากการเปรียบเทียบมุมมองของไทยกับแนวทางการออกแบบในระดับสากลพบว่า แนวความคิดการออกแบบสถาปัตยกรรมยั่งยืนของไทยยังไม่ครอบคลุมแนวคิดของการพัฒนาอย่างยั่งยืนทั้งหมด รวมทั้งยังมีมุมมองที่ค่อนข้างแคบกว่าแนวทางของทฤษฎีการออกแบบสถาปัตยกรรมยั่งยืนในระดับสากลอยู่อีกมาก ดังนั้นการปรับปรุงแนวทางการออกแบบสถาปัตยกรรมยั่งยืนของไทยให้เทียบเคียงกันได้กับแนวทางการพัฒนาแนวความคิดในระดับสากล รวมทั้งมีความกลมกลืนกับบริบทของประเทศไทย ทั้งในแง่ของการดำเนินชีวิตและนโยบายของประเทศ เช่น แนวคิดเศรษฐกิจพอเพียง จึงควรต้องได้รับการพิจารณาและพัฒนาเพื่อสนับสนุนแนวทางการพัฒนาอย่างยั่งยืนในระดับประเทศสืบไป

Keywords (คำสำคัญ)

Sustainable Development (การพัฒนาอย่างยั่งยืน)
Sustainable Architecture (สถาปัตยกรรมยั่งยืน)
Thailand (ประเทศไทย)

1. Introduction

Sustainability, sustainable development, and sustainable architecture are the terms that Thai people are familiar with for sometime. Similar to many countries, the ideas of sustainability, sustainable development and sustainable architecture are also recognized by the Thais as one of the current prominent trends. Sustainable architecture, which can be traced back to the early development during the 1970s, is now playing an important role, due to the realization of the environmental degradation.

The formation of sustainable development and sustainable architectural design at national and international levels are reviewed and analyzed in order to understand how the terms are currently conceptualized. Selected architecture and documents that represent overall concept of sustainable architecture are used for describing the contemporary trends. The first part of the article is the review of the idea of sustainability and sustainable development at national and international levels. Then the development of sustainable design is examined. The comparison between the national and international approaches to sustainable architecture will be made and lead to an appropriate guideline for Thai sustainable architecture.

The results of the study show that the current status of sustainable design in Thailand is still in its infancy. There are many rooms for development. So, instead of providing a checklist that may create confusion and uncertainty at this stage, this article intends to address the areas that are commonly ignored in Thai current development. However, a rough guideline can be found at the section that compares Thai current actions to international aspects.

2. Sustainability and Sustainable Development

The terms of sustainability and sustainable development have obviously soared to prominence because of the adverse effects on the environment, which are caused by human activities. Nowadays, there is little dispute that the balance of environmental resource demands is no longer sustainable. The origin of ecological awareness can be traced back to link with the new social movement, from the beginning of the movement at local level [1] and later became recognized and took a prominent place on the political agenda.

The term "sustainable development" was originally mentioned in the *'World Conservation Strategy'* by the World Conservation Union (IUCN) in 1980. Later on in 1987, the *'Brundtland Report,'* also known as *'Our Common Future'* by Gro Harlem Brundtland, the first female Prime Minister of Norway and the chairman of the World Commission on Environment and Development (WCED) [2], put more emphasis on sustainable development by giving a formal description of the term;

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [3]."

Inspired by *'Our Common Future,'* the United Nations Conference on Environment and Development (UNCED), or known as the Earth Summit, was held in 1992 in Rio de Janeiro, in which more than 100 leaders participated. The main document published by UNCED was the so called *'Agenda 21*,' which alerted people all over the world to change their attitudes toward environment and sustainability. There are many countries that responded to the agenda and set up their own "Local Agenda 21," to be a path toward their own sustainable development [4]. Many theories and programs were introduced,

encouraging people to adapt their behaviors for sustainability. Later in 1994, IUCN and International Institute for Environment and Development (IIED) published *'Strategies for National Sustainable Development.'* The document defines sustainable development as; *"improving and maintaining the well-being of people and ecosystems,"* which has the central concept of *"human systems are integral parts of ecosystems* [5]."

Considering the movements for sustainability and sustainable development in the world since the 1980s, sustainability is now playing a vital role in every step of development. Environment, society, and economy are the essential parts of sustainable development. These three parts have been used in the concept of sustainable development models in order to clarify and form an understandable image of the connections among them. Two popular diagrams used for describing sustainable development are in the form of three partially overlapping circles and also circles within circles [6]. The diagrams illustrate the relationships of the three principles as "weak" and "strong" relationships. The partially overlapping circles represent the so called "weak" sustainable development (Figure 1) in which the three principles are valued the same. Rather than a "weak" sustainable development, the better image of "strong" sustainable development is represented by the diagram of circles within circles (Figure 2). The diagram shows the relationships between the principles in a hierarchical order which highlights the environment as the most important principle. In short, the "strong" sustainable development illustrates a model of community with more sustainable status than the "weak" diagram does.

3. Sustainability and Sustainable Development in Thailand

The idea of sustainability and sustainable development in Thailand could be seen as related to the environmental problems, especially the problem about energy shortage as well as environmental degradation. Although the origin of the development of the terms seems parallel to what had happened worldwide, however, there are specific characters to the meaning of sustainability and sustainable development in Thailand.

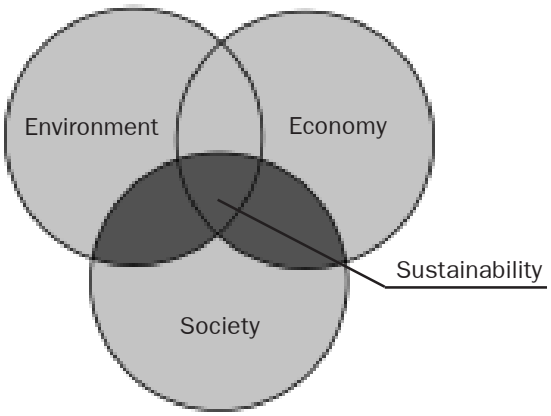

Figure 1. Weak sustainable development [6].

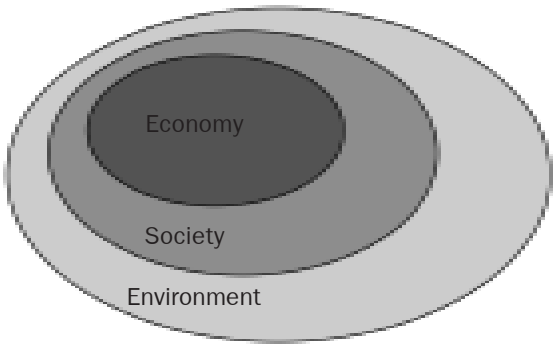

Figure 2. Strong sustainable development [6].

The roots of sustainability, sustainable development or similar ideas can be traced back to the Fifth National Economic and Social Development Plan (1982–1986), which is aimed at rural development and energy conservation [7]. Most of the early plans were focusing on encouraging only the industrial sectors. As a result, these plans became the factors that increase energy and natural resource consumption, which led to energy shortage as well as adverse effects on the environment in Thailand. The circumstances raised the awareness that Thailand were depending too much on imported oil. To address the issues, there have been several attempts to establish national policies in response to both energy and environmental problems.

In fact, the term sustainable development was officially mentioned in the Seventh National Economic and Social Development Plan (1992–1996). It is the first plan that stated the objectives of balancing the development of national and provincial economics, human resource, quality of life, and environment, in order to move toward sustainable development [8]. This initiative occurred around the same period of the Earth Summit. However the idea of sustainable development only recieved attention from the public after the economic crisis in 1997, during the period of the Eighth National Economic and Social Development Plan.

Recently, the Ninth National Economic and Social Development Plan (2002–2006) was launched with an aim to develop the country along a sustainable path [9]. The plan is base don His Majesty the King's philosophy of "Sufficiency Economy," which the origin of the term can be traced back to 1974 [10]. By following the Sufficiency Economy philosophy, it is believed that the philosophy will lead the nation to develop in a more secure development with more resilient and sustainable economy, better able to meet the challenges arising from globalization and other changes. The Sufficiency Economy prioritizes solidifying the national economic foundation over economic growth. The basic concept of a Sufficiency Economy is based on Thai culture and tradition. It is adapted from Buddhism philosophy by stressing "the middle path" as an overriding principle for appropriate conduct for populace at all levels [9]. In short, Sufficiency Economy is about encouraging people to realize what is enough for each person, learning to be satisfied with what each can have, or trying to be more self–reliant and self–sufficient without being too extravagance. This concept can also be considered as an essential part of the meaning of sustainable development given by WCED in 1987 as well. When a person only has what one should, in terms of a fair share of resources, this will greatly contribute to a sustainable future. In conclusion, while Sufficiency Economy shares similar ideas and concepts to the global sustainable development. However, it has been specially created according to Thai tradition.

4. Architecture and Sustainability

"Buildings and the built environment play a major role in the human impact on the natural environment and on the quality of life [11]."

Architecture is normally built and meant to stay in a useful order for at least several decades or even hundreds of years. Its performance, whether negative or positive, will cause an impact on the environment throughout its life span. Moreover, according to Brian Edwards [12], architecture is responsible for about half of total global resource consumption due to the use of materials, energy, water, and the loss of fertile farmland which is replaced by buildings. Since architecture and environment have a close relationship in

terms of cause and effect, better building and a more sustainable architecture will be one of the solutions toward sustainability.

After the issue of sustainability had been brought to the Earth Summit in Rio de Janeiro and agreement reached in 1992, The International Union of Architects (UIA) with The American Institute of Architects (AIA) responded to the issue by arranging the World Congress of Architects in Chicago in the following year. The Congress was attended by more than 10,000 design professionals from around the world and the signed document "Declaration of Interdependence for a Sustainable Future," which agreed on sustainable architecture as the framework for the 21st century, was created at the Congress [11].

4.1 The International Movement

The 1993 World Congress of Architects was the official declaration for sustainable architecture. However, the roots of sustainable architecture or environmental architecture or similar ideas can be traced back to centuries ago. Vitruvius's *'De Architectura'* or *'The Ten Books on Architecture'* might be the oldest evidence that suggests criteria of design related to environment, such as site selection, orientation, climate, and water supply [13].

Familiar ideas and practices can also be traced back to the late 19th century as, for example, William Morris's "Arts and Craft Movement," Rudolph Steiner's "Biodynamic Agriculture," Ebenezer Howard's "Garden Cities," the Regional Planning of Patrick Geddes and Lewis Mumford, as well as the "Organic Architecture" of Frank Lloyd Wright [14]. These ideas focus on the relationship between people and ecology, which is also recognized as a core of the later concept of sustainable architecture.

The ideas related to sustainable architecture have developed and been around for a while, even at the height of industrialization that has been dictating attitudes of society and activities for sometime. The terms "Ecological Design," "Green Architecture," and "Sustainable Architecture" emerged along the way and they share some similarities. In general, all the terms give a broad idea of a special type of architecture that was designed with concern for the environment. In details, these ideas suggest similar types of architecture and similar requirements for performance. However, the term "Sustainable Architecture" is linked to the current movement of sustainable development and its elements namely, environment, society, and economy, which suggests integration, and this is likely to renew the ideas behind ecological design and green architecture to bring into the current trend.

Evidence of the development of ecological design and green architecture can be examined from 1960s, when they were part of the environmental movement at that time. The classic 1962 book *'Silent Spring'* by Rachel Carson has created not only awareness of the polluted natural environment, but also led to the environmental movement in society from that time. Senator Gaylord Nelson was attached to the movement from 1962 and later found Earth Day in 1970 [15].

The environmental movement in the 1960s also inspired some architects to respond to the idea as portrayed in many books, for example, the 1963 book of Victor Olgyay *'Design with Climate: Bioclimatic Approach to Architectural Regionalism'* along with books from 1969 including Baruch Givoni's *'Man, Climate and Architecture,'* Amos Rappoport's *'House Form and Culture,'* and especially Ian McHarg's *'Design with Nature.'* The latter book has inspired a lot of architects to have more concern for the natural environment since it was first published and still remains so.

In addition to the expression of ideas in terms of books, there were also some experiments being undertaken during the end of this decade. The Farallones Institute at Berkley in the United States was founded by Sim Van der Ryn in 1969 to acknowledge and research into appropriate technology related to buildings. The Integral Urban House project was one of the experiments of the institute, later in 1973, which gave a model for self-reliant lifestyle that had been integrated with an urban house [16]. Another organization founded in 1969 was the New Alchemy Institute, by the Todds and their associates. The institute undertook experiments on appropriate technology for food production, energy, and shelter. The institute successfully built two Bioshelters, known as Arks, in the following decade [17].

Moreover, the innovation of eco-villages or co-housing which normally means the same type of community [18] emerged during the first half of the 1960s [19]. An eco-village or co-housing promotes interdependent ways of living, whether between human and human or people and the environment. The community normally encourages people to live together, next to each other, or to share some everyday life facilities such as kitchen or dining room, in order to bring people together. The relationships between people and nature are, for example, producing organic food for the community, using man-powered or animal-powered technology rather than machines, producing clean energy, and promoting a reduce, reuse, and recycle campaign [20].

The 1970s is the crucial period for all environmental design development. People in different professions, including architects, were pushed to realize human dependence on energy, especially oil, from the energy crisis during that time. In addition to the successful founding of the Earth Day in April 1970, which helped in promoting environmental awareness, people began to seek ways to reduce the use of energy. Architects were also seeking for design that would have less dependence on oil for energy. Alternative energy use and efficient use of resources were the main idea at that time.

More literature was published to promote the importance of the natural environment during the 1970s. There were some books that seemed to inspire and introduce architects to the subject such as the 1972 report for the Club of Rome *'The Limits to Growth,'* *'Small is Beautiful'* in 1973 by the economist Fritz Schumacher, an example of alternative energy use in *'Soft Energy Paths'* by the physicist Amory Lovins in 1977, as well as the architect Christopher Alexander's *'A Pattern Language'* (1977) and *'The Timeless Way of Building'* (1979).

The development of environmentally friendly architecture in this period became more tangible with all the help from the environmental movement during the 1960s and because of necessity due to the energy shortage at that time. Early examples of this architecture were centered on small scale buildings, especially housing. The aim was to build a building that had a relationship to its surrounding as well as the ability to conserve energy. The initial development trends of environmentally friendly architecture can be categorized into two main streams: energy conservation in architecture and a rediscovery of vernacular architecture.

4.1.1 Energy Conservation in Architecture

Due to the energy shortage in the 1970s, conservation seemed to be a solution for the time. The new design was adapted to fit the climate and to promote natural ventilation, in order to reduce the use of heating, cooling, and mechanical ventilation systems. Solar and wind power were encouraged and these alternatives were presented to the public. There were more technolo-

gical development and innovation to support the use of sunlight and wind as well as a better use of passive design. Solar collectors were installed on the roof to help with the heating using active systems, along with other passive techniques, for example, the use of thermal mass wall, skylights, and conservatories. Wind power was seen as a source of electricity, generated from a windmill type turbine generator. Biomass and biogas were also considered as power sources.

Building materials were also seen as an important issue in energy conservation. Local materials and non-toxic materials, especially wood that could be re-planted were selected as suitable materials. Stone, earth, and concrete were seen as energy efficient materials because of their insulation capacity. Moreover, the promotion of energy-efficient appliances in building was another practice that developed as part of the trend.

4.1.2 Rediscovery of Vernacular Architecture

The move toward vernacular architecture was seen as a solution at that era because of the fact that it shows the close relationship to the environment, uses less energy, and also responds to cultural aspects and beliefs. Design of this architectural type would normally utilize materials, forms, and decoration that followed vernacular architecture. The idea of energy conservation was not the main theme of this trend, so technologies related to this issue were generally not included. However, the passive techniques that were embodied in vernacular architecture were crucial to the success of this approach.

There are some examples of architecture during the 1970s that represent the trends and movements of the period. A project that shows the importance of social change is the Tinggarden Housing Project, the first rental co-housing in Denmark [20]. The trend of energy conservation can be examined in The Arks of the New Alchemy Institute [17], the Integral Urban House of the Farallones Institute [16], and the proposed Autarkic House of Cambridge University [21, 22]. Moreover, an example of vernacular type architecture can be given from the work of Hassan Fathy, an Egyptian architect. He is an example of an architect working toward a reinterpretation of vernacular architecture. His work has always been related to vernacular architecture even before the trend in the 1970s which inturn made Fathy one of the architects that gave inspiration to the movement. This conclusion is based on the fact that Fathy published his famous book *'Architecture for the Poor'* in 1977, which helped to spread his ideas and his earlier designs worldwide.

The 1980s was the decade of an introduction to sustainable development. Environmental awareness continued to remain a dominant issue along with recognition of some environmental degradation phenomena, such as ozone depletion and global warming. "The Montreal Protocol on Substances that Deplete the Ozone Layer" in 1987 was another attempt to respond to the issue. This led to the promotion of reducing the use of ozone depleting substances by the use of other substitutes.

Creation of an eco-municipality was another successful example of sustainable community development that happened in Europe during this decade. The main idea of the eco-municipality rested in the participatory system, where all the members decide their own future by themselves. The idea was developed around Sweden, Norway, Finland, and Denmark during the same period, and these countries later on founded the Nordic Eco-municipality group [18]. The group was used as an example in the 1992 Earth Summit to suggest a framework for sustainable development at the local level.

The development of alternative techno-

logies continued from the last decade. Solar and wind power remained essential alternative resources. Photovoltaic cells (solar cells) were widely used to generate electricity from the sun. Apart from technology, there was an idea related to ecology originally initiated as an agricultural technique in 1978 called "Permaculture" (permanent agriculture or permanent culture) [23, 24], developed by Bill Mollison and David Holmgren, and later on in 1980 the idea was developed to include both organic agriculture and healthy building together to create a better way of living. The idea of permaculture was later accepted and has inspired many architects internationally. The development of architecture during the 1980s was similar to the 1970s. The main stream was still related to the use of alternative technology. Photovoltaic cells were used for generating electricity along with the wind turbine generator from the 70s. There was a little change in architectural scale as the 70s centered on housing scale move to a wider scale in the 80s, as well as embracing the idea of community. There are some examples of architecture from 1980s that represent the trends and movements of the period. The Blueprint Farm by Pliny Fisk [25, 26], Block 103 by STERN [27, 28], and the eco-municipality of Overtornea in Sweden [18], are the examples of the community scale project.

In the 1990s, the promotion of sustainable development, which was introduced during the 1980s, was made a global concern by the successful 1992 Earth Summit, as well as the World Congress of Architects later in 1993. Environmental design techniques continued to develop, especially toward technology for energy conservation. More emphasis was put on the urban level during this decade because of the realization that the increasing urban population was putting more stress on the environment in terms of the need for food and energy.

During this period tools were created for measuring environmental impacts, and by doing so the results suggested a better way or friendlier way of building for the environment. Below are some examples of measurement systems that illustrate the trend of the period.

4.1.3 Embodied Energy

Embodied energy is the measurement of the energy used for the whole process of extracting and making building materials. The aim is to find the sum total of the energy necessary, from the raw material extraction, to transport, manufacturing, assembly, and installation, as well as the capital and other costs of a specific material, in order to produce a product or render any service. Materials that have a lower embodied energy can be assumed to have less impact on the environment, in terms of using less energy, compared to those with higher embodied energy.

4.1.4 Life Cycle Analysis/Assessment (LCA)

Life cycle analysis is a part of the ISO 14000 environmental management standards. It is the assessment of the environmental impact of a given product or service throughout its lifespan (cradle to grave). The goal of LCA is to compare the environmental performance of products and services (materials) so as to be able to choose the one with least affect on the environment. Durability, energy use for creation (embodied energy), maintenance, and recycling are all concerns of the evaluation.

4.1.5 Carbon Accounting

Carbon accounting is the process undertaken to measure the amount of carbon sequestered or the amount of carbon of which release into the atmosphere is avoided during the production of any products or services. The aim is to compare the amount of carbon dioxide created

and the available forest for absorbing it. Since carbon dioxide is one of the main greenhouse gases reinforcing the greenhouse effect and almost all goods and services require energy as a resource, carbon dioxide is one of the end-products that is causing environmental degradation.

4.1.6 Ecological Footprint Analysis

Ecological Footprint Analysis was developed by Mathis Wackernagel and William Rees. The analysis shows the area of land and water, human population would hypothetically need to provide the resources required to support itself and to absorb the wastes, given prevailing technology [29]. Ecological footprint is widely used as an indicator of environmental sustainability. The method approximates the amount of ecologically productive land and sea area required to sustain a population, manufacture a product, or undertake certain activities, by accounting for the use of land, energy, food, water, building materials and other consumables. It is commonly used to explore the sustainability of individual lifestyles, goods and services, organizations, industry sectors, regions, and nations. Ecological footprints have been used to argue that current human lifestyles are not sustainable. Studying or testing the measurements against any scale of human population could give a rough impact of the population on the environment, as well as suggesting ways to avoid it, for example through showing which aspects have the biggest impact.

4.1.7 Building Evaluation Systems

Building evaluation systems are aimed at evaluating impacts caused by buildings on the surrounding environment. Building evaluation systems are normally run by councils or government to encourage building performance, but are not yet established as law. Some examples of evaluation systems developed during the 1990s and adopted for use in different countries are BREEAM (Building Research Establishment Environmental Assessment Method) in the United Kingdom, LEED (Leadership in Energy and Environment Design) in United States, GBC (Green Building Challenge) initiated by Natural Resources Canada, HK-BEAM (Hong Kong Building Environmental Assessment Method) inspired by BREEAM, and a designer checklist DCBA (the four-variant method) of the European Green Cities Network, developed by EGCN partner Zonnige Kempen in Belgium. Later tools are, for example, NABERS (National Australian Built Environment Rating System) developed by Australian government and CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) developed by Japan Building Consortium.

The promotion of sustainable development and sustainable architecture has spread more concern for environmentally friendly buildings as well as developing definitions of what these terms mean, according to individual interests. However, there are some examples of environmentally friendly architecture from the 1990s that seem to have developed based on the concepts of the older environmentally friendly buildings created a couple decades earlier. The Southwell Autonomous House and Hockerton Housing Project by the Vales [21, 30], the Real Goods Solar Living Center by Sim Van der Ryn [31], and the urban Beddington Zero Energy Development (BedZED) by Bill Dunster architects [32, 33] are examples of interesting projects of this period.

4.2 The National Movement

Contemporary architecture in Thailand is influenced by global architectural trends. Since the sustainable architecture is one of the current prominent trends in architecture, the ideas and practices are also found in Thailand. Sustainable

architecture was formally introduced by the Association of Siamese Architect under Royal Patronage (ASA) to the Thai architectural community in 1999 or six years after the 1993 World Congress of Architects. There have been several attempts by ASA to promote sustainable architecture, which can be seen in the 1999 ASA's annual exhibition "Architects'99: Back to Basics: Thai Lifestyle," as well as in *'ASA: the Architectural Journal of the Association of Siamese Architect'* in the same year. Later in the 2000, The Council of Deans of Architecture Schools of Thailand (CDAST) with the Faculty of Architecture of King Mongkut's Institute of Technology-Ladkrabang (KMITL), and the National Energy Policy Office (NEPO), which was changed to the Energy Policy and Planning Office (EPPO) in 2002, arranged a seminar called "Green Architecture: The Sustainable Built Environment of the New Millennium." The seminar invited a number of architects in both practice and academia who are recognized as the front line of the field, for example, Professor Brenda and Dr. Robert Vale from the University of Auckland, New Zealand, Dr. Ken Yeang, originally from Sheffield University, UK, Professor Ross King from the University of Melbourne, Australia, and Professor Baruch Givoni from University of California, United States. This event affirmed the growing of interests related to sustainability in Thailand.

Before the official promotion of sustainable architecture in 1999, some ideas linked to sustainable architecture and green architecture can be traced back a couple of years earlier. The terms were mentioned as an individual perspective by a number of university lecturers in *'ASA,'* May 1996 [34-36] in a couple of issues of *'ASA.'* However, the meanings of sustainable architecture presented during the period were centered on building and building performances, which led to a strong foundation for the meaning of sustainable architecture in Thailand ever since, while the social aspects related to sustainability were not mentioned to any extent. Even though the aspects of building technology and energy conservation were seemingly introduced at the same period, the issue about energy conservation in architecture has become far more popular than concerns about sustainable building technology, from the promotion of energy conservation by the Energy Policy and Planning Office (EPPO).

It is quite interesting to point out that the promotion of sustainable architecture by ASA in 1999 had taken place after the economic crisis in 1997, which also had a big effect on the architectural community at that time. This promotion was set six years after the international promotion, which seems too long for an important issue like this. It could be argued that if there had been no economic crisis, Thai soceity would not realize the importance of sustainable development. Similarly, architectural community in Thailand might be more delay in promoting sustainable architecture, a response to sustainable development concept in architectural field.

Since 1999, the implementation and practice regarding to the trend in Thailand could be categorized into two main streams and one secondary stream [37]. The building technology/energy conservation and cultural/vernacular architecture are the two main streams, followed by the community and urban planning stream. In this article, these streams or approaches will be represented as "images." This term is used because of the reason, which was perfectly described by Williamson, T. (2003) [38], that an image can express both its common meaning of the visual image and the impressions or ideas within one's mind regarding to a particular subject. Since it can also be linked to subjective knowledge, recognition, beliefs, experiences, as well as values and emotions, the term "image" would be a better choice to portray the current situation of sustainable architectural trends in Thailand.

4.2.1 *The Image of Building Technology/Energy Conservation in Architecture*

There are several examples referring to sustainability and sustainable development according to the image of building technology/energy conservation in architecture from 1994 onwards. However, the overall conclusion of how to attain sustainable status is normally centered only on energy conservation, which is only partially true, and this cannot offer the whole possibility of achieving sustainability to an audience, thereby possibly leading to misunderstanding. Ideas about and meanings of sustainable architecture from this viewpoint were also quite limited. The idea that a sustainable house should be totally self-sufficient (off-grid) is one of the main implementation from the understanding of sustainable architecture of this image. This idea of a complete self-sufficient house has a close relationship to the Autarkic House of Cambridge University, which was developed during the 1970s. Even though, there has been some notions about living with pleasure or quality of life, the implementation was still limited to microclimate modification (thermal, lighting, visual, and acoustic comfort as well as indoor air quality).

The latest creation from the building technology/energy conservation image, the Bio-solar house [39], is a successful example of an integrated technology for energy conservation house in Thailand. It can be counted as a big step toward Thai sustainable architecture from the point of view of building technology/energy conservation image. However, there were several approaches that seemed to be absent from the project in relation to the international concept of sustainable architecture that has developed since 1960s. Firstly, the aspect of social and community cannot be included in the project from the fact that the project is built as a prototype and was not designed for any specific needs nor certain people, nor location, and has not been occupied, so the building performance during the post-occupancy period will never be monitored. The idea of complete self-sufficiency has also isolated the house from the real context, for example, the social aspect of the community. Secondly, the availability of facilities in the area should be another issue worth considerating. If the location has all the reticulated services available, ignoring the facilities might be considered wasteful. Thirdly, there is also uncertainty about the selected building materials. Although the main reason for the selection is the energy efficiency after installation, the energy usage for the whole lifespan (LCA) and the amount of toxin were not mentioned.

In short, the Bio-solar home is an advanced energy-efficient building, which is only partially involved in creating sustainable architecture and sustainability. With more aspects relating to sustainability taken into consideration, the project could move closer to the sustainable goal.

4.2.2 *The Image of Cultural/Vernacular Architecture*

Internationally, cultural, as relating to indigenous ways of life, or vernacular architecture is widely accepted as having a close relationship to sustainability and sustainable architecture because of its traditions relating to place. Vernacular architecture is often recognized as a role model of sustainable architecture by the ability to harmonize with its surroundings as well as respect to the environment. Practical practices of the knowledge are based on the availability of local materials and technologies, their immediate environment, as well as responses to cultural identity and lifestyle.

Nationally, Thai vernacular architecture has always been widely recognized among the Thais as a perfect way of living with nature. In the current situation where sustainability and sustainable architecture, which mainly promote living within

environmental limits, is globally becoming a prominent trend, Thai vernacular architecture is automatically assumed as an example of sustainable architecture as well as a way of sustainable living. For instance, the relationship between Thai vernacular architecture and sustainable lifestyle is clearly pointed out in the report published in 2004 by Silpakorn University [40]. There is, however, not enough evidence of any discourse on the relationships of Thai vernacular architecture and sustainability, or explanation regarding to the assumption appeared in the document so far [37, 41].

One argument against the assumption given by the image would be that sustainability and sustainable architecture are dynamic. There will inevitably be change and progress over time. When considering the term vernacular architecture as it is used when equated to sustainable architecture, as traditional culture equates to a sustainable way of life, this could lead to the question as to why vernacular architecture and the traditional way of life are now endangered and needed preservation? This argument shows possible conflicts, when the linkage between the subjects is unclear. Study and research dealing with the relationship between sustainability and both vernacular architecture and the traditional way of life will need more consideration.

In fact, sustainability and sustainable architecture are not about styles but more about ideas, concepts, philosophy, and ways of thinking, designing, and living. Similarly, vernacular architecture and the traditional way of life can be considered in the same pattern. They are not about the styles, but about the practical ideas and philosophy behind appearances, such as harmonization with nature and reflection of local culture, which can be applied in contemporary situations. The counterargument to the above question is that the endangered part of vernacular architecture and the traditional way of life is only its style, not the philosophy. This statement marks the initiative to further explore their relationships, and it will need more research and evidences to support this argument as well as more considerations in terms of how to accommodate the ideas of the past into contemporary uses. This will help celebrate vernacular architecture and the traditional way of life and, at the same time act as an example of a better practice.

4.2.3 The Image of Community and Urban Planning

The implementation of sustainability and sustainable development from the image of community and urban planning has the overall approaches closest to the international meaning of the terms. A considerable number of community development projects under the name "Baan Mankong Program," have been developed by the Community Organizations Development Institute (CODI), since 2003 [42]. The program provides a good example of the approaches to sustainable community development that have been carried out from the urban planning image. Most of the projects were based on a participatory process. Community members, local organizations, academic institutions, and temples were encouraged to take part in the project as well as the promotion of an interdependent lifestyle.

The program can be seen as a good example and a good starting point of sustainable community development in Thailand. The participatory system within the process of the program is the major key toward the social aspects of sustainable development as well as the success of the program. However, the implementation is centered more on the social and economic aspects and less on the environment. Since "Baan Mankong" is aimed at improving slum communities [42], the intention of social and economical condition seems reasonable enough to uphold the concept of sus-

tainable community, but less thought for the environmental aspect had made it less than perfect.

5. Guidelines for the Development of Sustainable Architectural Design in Thailand

The design of the built environment is normally based on two scales: individuals and communities. The review of the international concept of sustainable development and sustainable architecture not only shows the development of the ideas, but also indirectly provides a standard framework of sustainable architecture and sustainable community. The embodiment of principles and practices found in the case studies can be pointed out and summarized into four aspects [41]. The general aspects give overall ideas based on the basic principles of sustainable architecture and sustainable community. Environmental aspects concern about the well-being of the environment and microclimate, while social aspects involve human health and well-being. Economical aspects are those related to economy. Current Thai performances can be checked against each aspect to form a better understanding of the situation and the areas that need more attention. Table 1 shows the rate of attention of each image given to the aspects ranging from low, medium, and high.

Table 1. Rate of attention of the images given to the aspects of sustainable architecture.

Details	Images		
	Building Technology/Energy Conservation	Cultural/Vernacular Architecture	Community and Urban Planning
General Aspects			
– Design Criteria and Concept	⊙	⊙	⊙
– Knowledge Base in Design (disciplinary focus)	⊙	○	⊙
– Recognition of Project	⊙	⊙	⊙
– Impacts on Ecology, Society, and Economy	⊙	⊙	⊙
– Spatial Scales	⊙	⊙	⊙
– Level of Participation	○	⊙	●
– Response to Sustainability	○	○	○
Environmental Aspects			
– Site Selection	⊙	⊙	⊙
– Site Development	●	⊙	⊙
– Transportation	○	○	⊙
– Building Placement	●	●	○
– Land Design and Site Planning	⊙	⊙	⊙
– Building/Room Orientation	●	●	○
– Building Size	○	●	⊙
– Building Construction	⊙	⊙	⊙
– Building Material	⊙	⊙	⊙
– Building Technology	⊙	⊙	⊙
– Water Management	●	⊙	⊙
– Waste Management	●	○	○
Social Aspects			
– Air Quality	⊙	○	⊙
– Thermal Comfort	●	○	○
– Lighting and Acoustic	●	○	○
– Social and Security	⊙	●	●
– Special Needs and Participation in Design	⊙	●	●
Economical Aspects			
– Economic Activities	●	●	●
– Constructing Cost	⊙	⊙	●
– Economy of Energy Conservation	●	○	○

● high rate of attention ⊙ medium rate of attention ○ low rate of attention

The overall attention given to the aspects is mainly at the moderate level. This can be inferred that some considerations are given to particular aspects, but it may not intentionally direct to the concept of sustainability. For example, all three images were evaluated to have only medium rate of attention to the site selection scheme. This judgment is based on a lack of evidence that site selection is studied under the sustainability point of view, although each image typically concerns the aspect as the common criterion practicing in architectural design. The approaches of site selection based on sustainability concepts should include not only topography and geography of the site, the effects on well-being of occupants, or economic feasibility and profits, but also the concern for environmental impacts, the possibility of using the brown field site instead of replacing the fertile farm land, alternative means of transportation, encouragement of local culture, resource availability, and the potential of self-sufficiency.

According to the result of the study, the approaches of Thai sustainable design still cannot capture the whole idea of sustainability concerns, which involves all of the aspects and their interconnections. Instead of creating a complete sustainable architecture, which responds to sustainable development concept that relates to environment, society and economy, the development of sustainable architecture in Thailand merely creates images of sustainable architecture, which often serve particular components of sustainability. The current images of sustainable architecture in Thailand concentrated on different components and levels of sustainable development. The image of building technology/energy conservation in architecture concentrates more on economy and individual comfort than the environment as a whole and very little on society; the image of cultural/vernacular architecture gives more interests to social and environmental issues; while the image of community and urban planning considers more on society and economy than environment and built environment.

As the article introduces a number of areas that need more consideration, as well as there are only a few projects or documents that claimed to use or fully explain the idea of sustainable architecture, the development of sustainable architectural design in Thailand can be identified as being at the early stage. However, some presumptions already formed and began to create confusions. Before getting too deep on providing a checklist of an appropriate practice for sustainable architectural design in Thailand, a strong foundation should be built by a better understanding. Three following steps are suggested for an overall frame-work of a process to achieve a suitable sustainable architecture for Thailand.

5.1 Step 1: A Better Understanding toward Sustainability and Sustainable Architecture

Every architect should have a better understanding of sustainability, sustainable development, and sustainable architecture. The implementation and practice in each image should be reconsidered and identified the way to develop further, such as encouraging more research and experiment. Plenty of tools and knowledge related to sustainability, sustainable development, and sustainable architecture are not yet commonly known to Thai architects, for example, LCA, Embodied Energy, Ecological Footprint, Toxicity of Material, etc. Moreover, local knowledge involving material, appropriate technology, vernacular architecture, and local wisdom is also important in building appropriate framework for sustainable architecture in Thailand. An immediate task is to master the local knowledge and link it to the international knowledge and practices, in order to form a concrete foundation of Thai sustainable architecture.

5.2 Step 2: An Integration of Images

Sustainability, sustainable development, and sustainable architecture are about holistic approach. Implementing ideas separately could be considered stepping backwards. Completing the first step not only contributes to a better understanding of sustainability and related concepts, but also puts more emphasis on other important aspects as well. According to the study, each image has its own strong and weak points; integrating every strong point is considered appropriate. With a better understanding of sustainability and sustainable architecture in Step 1, the integration could be easier and more efficient.

In fact, there have been several attempts at integration between images. The image of building technology/energy conservation and the image of cultural/vernacular architecture are the most preferred subjects for integration; possibly because, they share a common interest in architecture. The major topic of interest concerns energy conservation and energy efficiency [43-46] followed by building technology and materials [47]. These attempts to integrate a few topics of the different images show a good starting point. However, it will need more integration in various subjects to cover all of the ideas behind the images.

Completing both steps will reduce the boundaries between the images that are the main obstacle to develop sustainable architecture. Because sustainable architecture is a philosophy, a concept, or an attitude, it should not belong to any image in particular, but is an integral part of all images.

5.3 Step 3: Linking Sustainable Architecture to Thai Sustainable Development Concept

The philosophy of Sufficiency Economy is developed based on Thai culture. It is about encouraging people to be more self-reliant and self-sufficient. This concept can be considered as an essential part of the meaning of Thai sustainable development. Relating sustainable architecture to the Sufficiency Economy can be seen as linking it to the national policy of sustainable development. Furthermore, since the philosophy suggests a practical lifestyle that is inspired by the traditional lifestyle, it celebrates Thai identity along with a chance for a better life and personal well-being by practicing self-reliant and self-sufficiency. Integrating Sufficiency Economy into sustainable architecture will also bring Thai identity to the approach. This is another crucial step toward a sustainable architecture and sustainable development that is unique to Thailand.

The concept of Sufficiency Economy can be applied to every aspect of sustainable architecture. An example of Sufficiency Economy concept application in sustainable design can be given under the Site Development scheme within the Environmental Aspect (Table 1). In addition to following sustainable design concept, a building can be designed with a consideration for an appropriate amount of open space and equipment to promote self-sufficient lifestyle. The provision will encourage the ability to produce food (fruit and vegetable) and generate necessary resources from the immediate environment (water and energy).

The achievement of all steps will provide a better understanding as well as possibly improve the current approaches of sustainable design. An appropriate checklist can be provided after the completion of these steps, because it is supported by the accumulative knowledge through stages.

6. Conclusion

The investigation of the formation of sustainability, sustainable development, and

sustainable architecture at national and international levels which contribute to a better understanding of sustainability concept would lead to a better implementation. A better way to develop the concept of sustainable design in Thailand is to complete a three-step framework, which is a better understanding of sustainability and sustainable architecture, an integration of images, and link it to the Thai concept of sustainable development (Sufficiency Economy).

Even though the term sustainable architecture has been formally introduced to the Thai architectural community in 1999, the practices of sustainable design in Thailand are still limited. Moreover, the approach is divided and unclear. The evidence of presumptions involving the meanings and approaches of sustainable architecture is found and starts to create confusion. The article suggests the need to revise the concept of sustainable architecture in Thailand and points out the areas that need more attention. An initial guideline for sustainable architecture is provided to give a rough idea of the aspects that should be addressed. But, a detail guideline for practice architects can be made after the accomplishment of the third step, as it responds to the concept of sustainable design and Thai identity. Although the further development and creation of a guideline or checklist is important to the practice architects to produce a better architecture and elevate Thai architecture status closer to a more sustainable level, a better understanding is still an immediate and ultimate goal.

References

[1] Van der Heijden, H. (1999). Environmental movements, ecological modernization and political opportunity structure. In C. Rootes (Ed.), Environemental movements: Local, national and global (pp. 199-221). London: Frank Cass.

[2] Dieren, W. V. (Ed.) (1995). Taking nature into account: A report to the club of Rome. New York: Springer-Verlag.

[3] WCED. (1987). Our common future. UK: Oxford University Press.

[4] Wadhwa, L. C. (2002). Global perspectives in sustainable urban environments. In C. A. Brebbia, et al. (Eds.), Proceedings of second international conference on sustainable city "The sustainable city II": Urban regeneration and sustainability. (pp. 3-11). Segovia, Spain.

[5] IUCN. (1997). Indigenous peoples and sustainability: Case and actions. Utrecht, The Netherlands: International Books.

[6] Hart, M. (1999). Guide to sustainable community indicators (2nd ed.). North Andover, MA: Hart Environmental Data.

[7] Office of the National Economic and Social Development Board (NESDB). (2001). The fifth national economic and social development plan (1982-1986). Retrieved August, 19, 2003, from http://www.nesdb.go.th/plan/data/plan5/

[8] Office of the National Economic and Social Development Board (NESDB). (2001). The seventh national economic and social development plan (1992-1996). Retrieved August, 19, 2003, from http://www.nesdb.go.th/plan/data/plan7/

[9] Office of the National Economic and Social Development Board (NESDB). (2001). The ninth national economic and social development plan (2002-2006). Retrieved August, 19, 2003, from http://www.nesdb.go.th/plan/data/plan9/

[10] Phanthasen, A. (2003). การประยุกต์พระราชดำริเศรษฐกิจพอเพียงกับอุตสาหกรรมขนาดกลางและขนาดย่อม [The application of His Majesty the King's sufficiency economy to small and medium industry]. Bangkok, Thailand: Thai Wattana Panich.

[11] The International Union of Architects (UIA). (1993). Declaration of independence for a sustainable future: UIA/AIA World Congress of Architects, Chicago. Retrieved November 6, 2004, from http://www.uia-architectes.org/texte/england/2aaf1.html

[12] Edwards, B. (2001). Design challenge of sustainability. In H. Castle, & B. Edwards (Eds.). Green architecture: An international comparison. (pp. 20-31). London: Wiley-Academy.

[13] Vitruvius. (1960). The ten books on architecture (M. H. Morgan, Trans.). New York: Dover Publication. (Original work published 1914).

[14] Van der Ryn, S., & Cowan, S. (1996). Ecological design. Washington DC: Island Press.

[15] EnviroLink Network. (n. d.). History of earth day. Retrieved November 16, 2004, from http://earthday.envirolink.org/history.html

[16] The Farallones Institute. (1979). The intergral urban house: Self-reliant living in the city. San Francisco, CA: Sierra Club Books.

[17] Todd, N. J., & Tood, J. (1984). Bioshelters, ocean arks, city farming: Ecology as the basis of design. San Francisco, CA: Sierra Club Books.

[18] James, S., & Lahti, T. (2004). The natural step for communities: How cities and towns can change to sustainable practices. Gabriola Island, BC: New Society Publishers.

[19] Milman, D. (1994). Where it all began: Cohousing in Denmark. Retrieved December 18, 2004, from http://www.cohousing.org/resources/library/history.html

[20] McCanant, K., Durrett, C., & Hertzman, E. (1994). Cohousing: A contemporary approach to housing ourselves. (2nd ed.). Berkeley, CA: Ten Speed Press.

[21] Vale, B., & Vale, R. (2000). The new autonomous house: Design and planning for sustainability. London: Thames & Hudson.

[22] Techincal Research Division, Department of Architecture, University of Cambridge (Director: Pike, A.). (1974). SRC/DOE autonomous housing study: The autonomous house research programme. UK: Department of Architecture, University of Cambridge.

[23] Mollison, B., & Holmgren, D. (1978). Permaculture one: A perennial agriculture for human settlements. Stanley, Tasmania: Tagari.

[24] Mollison, B. (1979). Permaculture two: Practical design for town and country in permanent agriculture. Stanley, Tasmania: Tagari.

[25] Tilley, R. D. (1991). Blueprint for survival. Architecture, 80(5), 64-70.

[26] Moore, S. (1997). Technology and the policies of sustainability at blueprint demonstration farm. Journal of Architecture Education, 51(1), 23-31.

[27] Seante Department of Urban Development. (n.d.). Model project block 103: The experiment proves itself to be productive. Retrieved January 5, 2005, from http://www.stadtentwicklung.berlin.de/umwelt/klimaschutz/berlin_spart_energie/en/bauen_wohnen/modellprojekt_103.shtml

[28] Wines, J. (2000). Green architecture. Koln, NY: Taschen.

[29] Wackernagel, M., & Rees, W. (1998). Our ecological footprint: Reducing human impact on the earth. Gabriola Island, BC: New Society Publishers.

[30] White, N. (Ed.). (2002). Sustainable housing schemes in the UK: A guide with details of access. Nottinghamshire, UK: Hockerton Housing Project.

[31] Van der Ryn Architects. (n.d.). Real goods solar living center. Retrieved January 13, 2005, from http://www.vanderryn.com/va/index-projects.html

[32] BedZED. (n.d.). About: What is BedZED?. Retrieved October 5, 2003, from http://www.bedzed.org.uk/main.html

[33] Bill Dunster Architects. (2002). The housing design awards 2000-BedZED, winner of the sustainability award & most promising scheme. Retrieved October 5, 2003, from http://www.zedfactory.com/bedzed/bedzed.html

[34] Boonyatikarn, S. (1996, May). สถาปัตยกรรมสำหรับอนาคต [Architecture for the future]. ASA, 12-16.

[35] Chindawanik, T., & Chompunich, R. (1996, May). สถาปัตยกรรมแห่งชีวิต [Green architecture]. ASA, 44-48.

[36] Chindawanik, T., & Wuthivorawung, S. (1996, May). Sustainable architecture. ASA, 49-53.

[37] Thanapet, K. (2005). วาทะกรรมของสถาปนิกไทยที่มีต่อเรื่องความยั่งยืนในรอบ 10 ปี [The discourses of Thai architects on sustainability]. Proceedings of Hompoom-Sathapattayapatha'04: Architectural Way, Communal Way, Folkway, 20-1 - 20-25.

[38] Williamson, T. (2003). Understanding sustainable architecture. London: Spon Press.

[39] Boonyatikarn, S. (2004). บ้านชีวาทิตย์: บ้านพลังงานแสงอาทิตย์ เพื่อคุณภาพชีวิตผลิตพลังงาน [Bio-solar home: Powered by the sun]. Bangkok, Thailand: Chulalongkorn University Press.

[40] Panin, O. (2004). รายงานสรุปชุดโครงการภูมิปัญญาท้องถิ่นในเรือนชุมชนและนิเวศวิทยาวัฒนธรรมการอยู่อาศัยที่ยั่งยืนของคนไทยในภาคตะวันตก [Local wisdom in houses, communities, and cultural ecology for sustainable living of Thai people in western region]. Bangkok, Thailand: Silpakorn University.

[41] Hengrasmee, S. (2005). รายงานฉบับสมบูรณ์ โครงการศึกษาแนวทางการออกแบบสถาปัตยกรรมยั่งยืนในประเทศไทย [The study of sustainable architectural design in Thailand]. Phitsanulok, Thailand: Faculty of Architecture, Naresuan University.

[42] Community Organizations Development Institute (CODI). (n.d.). รู้จักกับโครงการบ้านมั่นคง [Baanmankong]. Retrieved August 20, 2007, from http://www.codi.or.th/baanmankong/index.php?option=displaypage&Itemid=47&op=page&SubMenu=

[43] Boonyatikarn, S., & Chindawanik, T. (1993). การวิเคราะห์สภาวะน่าสบายและสภาพแวดล้อมที่เกี่ยวข้องของอาคารสถาปัตยกรรมไทย [An evaluation of thermal comfort and related variables in Thai architecture]. Bangkok, Thailand: Chulalongkorn University Press.

[44] Chindawanik, T. (1999, May). สถาปัตยกรรมไทยกับการปรับเย็นตามธรรมชาติ [Thai architecture and natural passive cooling]. Document for the seminar on "Architect'99" Back to basic: Thai lifestyle, Bangkok, Thailand.

[45] Osiri, N. (2002). ภูมิทัศน์หมู่บ้านพื้นถิ่น: ภูมิปัญญาเพื่อการประหยัดพลังงานและการพัฒนาอย่างยั่งยืน กรณีศึกษาหมู่บ้านตาลเหนือ อำเภอฮอด จังหวัดเชียงใหม่ [Landscape of local villages: Local wisdom for energy conservation and sustainable development: Case study Tan Nua Village, Amphor Hod, Chiang Mai]. Sarasatr 06(45), 129-144.

[46] Jitikhajornwanich, K. (2004). สภาวะสบายและการปรับตัวเพื่ออยู่แบบสบายของคนในท้องถิ่น [Thermal comfort and adaptability to living for local people]. In O. Panin, รายงานสรุปชุดโครงการภูมิปัญญาท้องถิ่นในเรือนชุมชนและนิเวศวิทยาวัฒนธรรมการอยู่อาศัยที่ยั่งยืนของคนไทยในภาคตะวันตก (pp. 7.1-7.14). Bangkok, Thailand: Silpakorn University.

[47] Wongmahadlek, P., Tovivich, S., & Panyakaew, S. (2547). วัสดุและการก่อสร้างเรือนพื้นถิ่นในการอยู่แบบยั่งยืนของไทย [Material and construction system in Thai vernacular house for sustainable living]. In O. Panin, รายงานสรุปชุดโครงการภูมิปัญญาท้องถิ่นในเรือนชุมชนและนิเวศวิทยาวัฒนธรรมการอยู่อาศัยที่ยั่งยืนของคนไทยในภาคตะวันตก (pp. 6.1-6.7). Bangkok, Thailand: Silpakorn University.