PREFERENCES FOR SUSTAINABLE DESIGN

The Roles of Cognitive Evaluation, Environmental Knowledge, Environmental Attitudes, and Culture

Takemi Sugiyama

A Thesis submitted in fulfilment of
the requirement for the degree of
Doctor of Philosophy

Faculty of Architecture
The University of Sydney

August 2002

STATEMENT OF ORIGINALITY

This thesis is my original work, and has not been submitted, in whole or in part, for a degree at this or any other university. Nor does it contain, to the best of my knowledge and belief, any material published or written by another person, except as acknowledged in the text.

Takemi Sugiyama

APPROVAL OF THE HUMAN ETHICS COMMITTEE

The Human Ethics Committee of the University of Sydney granted approval for the survey component of this research (Ref No. 00/03/38).

ABSTRACT

Sustainable design has been studied, tested, and built to improve sustainability of the environment. In its construction, designers often focus on the biophysical aspects without paying attention to sociocultural aspects. However, the research literature suggests that the effectiveness of sustainable design may be enhanced by considering the sociocultural aspects. Based on this proposition, this thesis explored people's perception of sustainable design. The concept of *environmental preference* was employed as a central theoretical construct to investigate this topic.

The objectives of the study were: to clarify to what extent people prefer sustainable design, to understand salient perceptual dimensions of sustainable design, to examine the effects of information on people's cognitive evaluation of and preferences for sustainable design, to construct and test a hypothetical model that accounts for preferences for sustainable design, and to examine cultural differences between Japanese and Australian participants in cognitive evaluation and preference.

Two hundred and thirty-five undergraduate students from Japan and Australia rated photographs of 11 design examples in terms of preference and evaluation of sustainability. Their environmental knowledge and attitudes were also measured. Different levels of information about sustainability were given to the participants to assess the effects of information on preference and cognitive evaluation.

The findings suggest that the participants tend to prefer design examples they consider sustainable. It was suggested that conformity to cultural values, visibility of sustainability, and perceived tidiness are salient factors influencing preference. Specific information was found to have significant effects on evaluation, but its effects on preference are limited. The examination of hypothetical models suggests causal effects of cognitive evaluation on preference and a small influence of environmental attitudes on preference. Cultural comparisons between the two countries indicated more similarities than differences in their responses to sustainable design.

The findings supported the importance of cognitive evaluation in people's preferences for sustainable design. To make sustainable design preferable, thus more acceptable to a society, this study recommends that architects and other environmental designers and managers pay attention to a range of visual aspects of sustainable design. Future research directions were suggested to further study people's preferences for sustainable design.

To my parents

ACKNOWLEDGEMENTS

Many people have helped and advised me in completing this thesis. I am indebted to them all. I would like to acknowledge some of them with particular gratitude. First of all, I wish to thank my supervisor, Professor Gary Moore. Since the beginning of my candidature at the University of Sydney, he has been always supportive and encouraging. Without his insightful advice based on his broad experience and knowledge, this thesis would not have been completed. My associate supervisor, Dr Richard Lamb, also provided me with helpful comments in various aspects of the thesis. I am grateful for the three examiners, Dr Paul Gobster, Associate Professor Florian Kaiser, and Dr Ray Green, who spent time and effort to read my thesis. Their comments were very thoughtful and constructive and helped to improve the quality of the thesis. Data collection required help from many people. I would like to thank Professor Ryuzo Ohno, Professor Toshihiko Sako, Professor Hirofumi Minami, Professor Akio Hayashi, Associate Professor Toshiyuki Isoi, and Dr Ray Green for their efforts to locate research participants. I also thank all the respondents who participated in my study. A number of researchers gave me helpful advice in various stages of my study. I gratefully acknowledge comments and advice from Dr Glen Hill, Professor Joan Nassauer, Professor Ryuzo Ohno, Professor Toshihiko Sako, Professor Robert Thayer, Professor Helen Ross, and Associate Professor Tomoya Yashiro. Discussions with colleagues, Mr Mike Steven, Mr Rohan Lulham, Mr Alex Summerfield, and Ms Gina Kuo, were also valuable in developing ideas and clarifying details of this thesis.

Finally, I owe special thanks to my wife, Fujiko. She has been very patient while I was occupied with the writing of my thesis. I am deeply grateful for her wholehearted support during this very stressful time.

TABLE OF CONTENTS

FIGURES

TABLES

Chapter One

INTRODUCTION

A New Approach to Sustainability

It is common understanding that environmental problems are one of the most serious threats to the future of humanity (Oskamp, 1995). Humans have been quite "successful" in building up the population, covering the most part of the land with settlements, and securing and using a large portion of the earth's resources (Milbrath, 1989). Particularly in the last one hundred years, humans have exploited resources on the earth—air, water, land, and biota—on a large scale and at an unprecedented rate (Kates, Turner, & Clark, 1990). As a result, the life-support systems of today's environment are in serious danger (Goudie, 2000). If human societies are to survive and prosper under current conditions, we need to act immediately and effectively to resolve or alleviate environmental problems (Gorham, 1997).

The term *sustainability* emerged in the late 1980s to encapsulate issues related to environmental destruction, depletion of resources, and the survival of the species on the earth (World Commission on Environment and Development [WCED], 1987). The concept of sustainability can be defined as maintaining capacities of the environment, which include provision of various environmental services such as resources, life-support systems, assimilation of waste, and biodiversity (Jacobs, 1991). The idea emphasises that environmental capacities be maintained for future generations (WCED, 1987). The idea of sustainability is multidisciplinary. It involves a wide range of disciplines including but not limited to biology, ecology, chemistry, agriculture, forestry, architecture, engineering, economics, politics, and law (Gardner & Stern, 1996). Considerable effort has been made in these areas to achieve sustainability in our societies. Our environment, however, is still far from being sustainable (e.g., Oskamp, 1995; Southwick, 1996).

There are three main approaches to sustainability: biophysical, social, and economical (e.g., Goodland, 1995; Ross, Dovers, Sexton, & Roger, 1994). Although economy is an important element of sustainability, this thesis is interested in the former two approaches. In the bio-physical approach, physical and ecological interventions to the environment are means to achieve sustainability. Methods employed in this category include the use of alternative energy, systems to reduce harmful emission, energy saving technologies, environmentally benign materials, and the use of biological processes (e.g., Anink, Boonstra, & Mak, 1996; Kibert, 1999; Gipe, 1995; Lyle, 1994; Malin, 1999). In the social approach, environmental problems are regarded as a consequence of the aggregate of human behaviour. People's behaviour patterns in relation to the environment and the way to alter them are the main concerns in the social approach. Intervention strategies such as incentives/disincentives, communication/education, project participation, and social support have been examined and applied in order to modify individual and social group behaviour patterns (e.g., Dwyer, Leeming, Cobern, Porter, & Jackson, 1993; Gardner & Stern, 1996; Oskamp et al., 1991).

Although these two approaches are normally considered independent, it seems worthwhile to find a way to integrate them and seek a new way of approaching sustainability. An important proposition of this thesis is that strategies for sustainability that address only the physical and ecological aspects of the environment are disregarding important opportunities to increase their overall effectiveness. Physical and ecological strategies could tap new "resources" by accessing the social aspect of the environment. For instance, some of the physical approaches would obviously be more effective if they were adopted widely in a society. People's active maintenance and care of sustainable design may also contribute to overall sustainability. In this sense, what is needed is a physical approach that works in cooperation with people. This thesis addresses issues regarding this new approach to sustainability.

Research Topic and Questions

In order to explore this new approach to sustainability, this thesis focuses on the social aspect of sustainability. The research topic of this study is *sustainable design*, which refers to a built environment designed to improve sustainability by resolving or mitigating particular environmental problems. Many examples of sustainable design have been developed to date. They are quite effective in reducing energy consumption, recycling resources, and diminishing environmental impacts. However, it has been criticised that sustainable design constructed so far has relied too much on technological and ecological solutions and has tended to neglect their sociocultural aspects (e.g., B. Edwards, 2001; Milbrath, 1995; Nassauer, 1995b). Little research has explored the interaction between people and sustainable design.

The sociocultural aspect examined theoretically and empirically in the present study involves the concept of *environmental perception*. Perception of the environment has a vital importance in the relationships between people and the environment (Ittelson, 1978). Environmental perception mediates people's behaviour in the environment. Since the world is heavily dominated by human beings, our perception of and resulting behaviour in the environment will ultimately affect the way the environment is used and protected (Nassauer, 1997a). The importance of the perception of sustainable design is further underscored when we consider that more and more people are participating in environmental design decision-making processes in various ways (e.g., Perkins, Brown, & Taylor, 1996).

The fundamental objective of the thesis is to obtain a better understanding of factors influencing people's perceptions of sustainable design. It is believed that understanding perception of sustainable design can yield insights into the new approach to sustainability in which the physical, ecological, and social approaches cooperate to achieve the same goal. In this exploration, the thesis employs the concept of *environmental preference*. Based on an analysis of the recent literature in this area, development of a theoretical model, and the results of empirical research conducted in Japan and Australia, this thesis aims to inform researchers, environmental designers, and managers involved in sustainable design about the significance of *preferences for sustainable design*, and salient environmental, perceptual, and personal factors that influence people's preferences for sustainable design.

The study explores several constructs for these purposes. First, the thesis revolves around the concept of environmental preference. The study of environmental preference aims to measure and identify environmental patterns people appreciate (Kaplan & Kaplan, 1982b). Since preferences reflect basic human needs and wants (S. Kaplan, 1987), it can be argued that preference for a certain environment represents the extent to which the environment is accepted by people. Environments people prefer are more likely to be acknowledged and accepted by the public, thus they are more likely to be sustained by appropriate human care and stewardship (Nassauer, 1997a). In this sense, it is agreed that increasing people's preference for sustainable design will contribute toward promoting sustainability in the environment.

Another important construct of the study is the *evaluation of sustainability*. To investigate the relationship between preference and sustainability empirically, it is necessary to identify the degree of sustainability achieved by a certain built environment. However, since the idea of sustainability involves an intricate web of relationships at many levels, no physical comprehensive measure of sustainability exists (Bell & Morse, 1999; Farrell & Hart, 1998). For this reason, the degree of sustainability as "seen by" or, more properly, assessed by individuals is used in this study. Thus, sustainability in this thesis is measured as individual perceptual evaluation.

In addition to preference and evaluation of sustainability, people's impressions of sustainable design are included in the study. Personal factors such as environmental knowledge and attitudes are also measured in this thesis. It will be hypothesised that environmental knowledge and attitudes have effects on preferences for and evaluation of sustainable design.

With the constructs outlined above, the study will identify, first, to what extent people like or dislike sustainable design. The actual research question will be the relationship between people's preference for sustainable design and their evaluation of sustainability. The study also tries to understand salient dimensions involved in the perception of sustainable design. An important question of the research relates to the effects of information concerning sustainability on preference. Different levels of information will be provided to groups of randomly assigned participants, and their effects will be examined. It will be hypothesised that certain types of information will have some impacts on participants' evaluation of sustainability and consequently their preferences for sustainable design. A comprehensive theoretical model of preferences for sustainable design involving the evaluation of sustainability, environmental knowledge, and attitudes will be proposed in this thesis. Using the empirical data obtained, the thesis will test how well this model explains preferences for sustainable design. Finally, cultural differences in preferences and evaluation of sustainability will be examined in this thesis.

Environment-Behaviour Studies

Because this thesis is mainly concerned with human responses to the environment, knowledge and methodologies from the field of environment-behaviour studies (EBS) are employed extensively. As a discipline, EBS is interested in the interaction between people and the environment. Moore (1987) defines EBS as follows:

> Environment and behavior is the study of the mutual relations between the sociophysical environment at all scales and human behavior at all levels of analysis, and utilization of knowledge thus gained in improving the quality of life through better informed environmental policy, planning, and design. Environment and behavior research focuses on the interdependence of physical environmental system and human systems and explicitly includes both environmental and human factors. (p. 1360)

It is possible to summarise the relationships to be discussed in this study using knowledge from EBS. Lewin (1967), one of the forerunners of EBS, provided the following conceptualisation of environment and behaviour:

$$B = f\ (P \cdot E)$$

The formula signifies that person's behaviour (*B*) is a joint function of personal factors (*P*) and the perceived environment (*E*). Application of this formula to the current study can be described as follows:

$$\begin{matrix}\textit{Preferences for} \\ \textit{sustainable design}\end{matrix} = f\ \left(\begin{matrix}\textit{Environmental knowledge,} \\ \textit{Environmental attitudes,} \\ \textit{Culture}\end{matrix} \cdot \begin{matrix}\textit{Evaluation of} \\ \textit{sustainability}\end{matrix} \right)$$

As the equation indicates, the study postulates that preferences for sustainable design are a function of evaluation of sustainability and personal factors such as environmental knowledge, attitudes, and culture. The study examines the hypothetical relationships between these constructs in several ways.

As well as contributing to the field of sustainability, this study may contribute some knowledge to the field of EBS. Through the investigation of preferences for sustainable design, the current study aims to expand the general concept of environmental preference. It can be argued that the study of environmental preference to date has been concerned with "affective" reactions to the environment. The current study tries also to identify the effect of "cognitive" elements (in this case, the evaluation of sustainability) on preference. The relationship between affect and cognition is an important issue in the field of EBS (e.g., S. Kaplan, 1987, 1988b) and in the social sciences (e.g., Zajonc, 1980). Findings from this study may add knowledge as to the role of cognition in preferences for sustainable design.

Organisation of the Thesis

This thesis consists of seven chapters. This chapter gives the outline of the background and purposes of the thesis.

Chapter 2 briefly summarises the current issues related to environmental problems and the idea of sustainability. To fully understand the gravity of the situation, Chapter 2 first demonstrates the extent of global environmental changes caused by human beings. Then the concept of sustainability, which was developed to cope with environmental crisis, is discussed along with a brief description of its history as well as three different types of means to improve sustainability of the environment.

Chapter 3 explains that industries associated with the built environment are major consumers of resources. This implies that a great benefit can be gained by addressing sustainability issues in the built environment. The chapter introduces the concept of *sustainable design*, which refers to any built environment designed to improve sustainability. Through the discussion of different types of sustainable design, Chapter 3 argues that current practice of sustainable design depends more on technological or ecological means, and pays less attention to its sociocultural aspect. Possible reasons for the lack of interest in this aspect of sustainable design are discussed.

Chapter 4 first argues the importance of environmental perception based on the literature in EBS. In order to examine people's perception of sustainable design for the purpose of this research, the concept of *environmental preference* is introduced and elaborated in this chapter. The thesis points out that a conventional model of environmental preference may need to be improved to discuss preferences for sustainable design. An expanded model of preference that includes a cognitive component as an important factor influencing preferences for sustainable design is proposed. The chapter then discusses the significance of environmental preferences in sustainable design. Based on the recent literature in environmental sustainability and EBS, Chapter 4 also reviews what has been studied in the area related to the perception of sustainable design. Figure 1 illustrates the composition of the thesis from general backgrounds to specific research questions.

Research questions and methods are discussed in Chapter 5. The chapter describes six research questions and hypotheses associated with the questions. It then presents the research

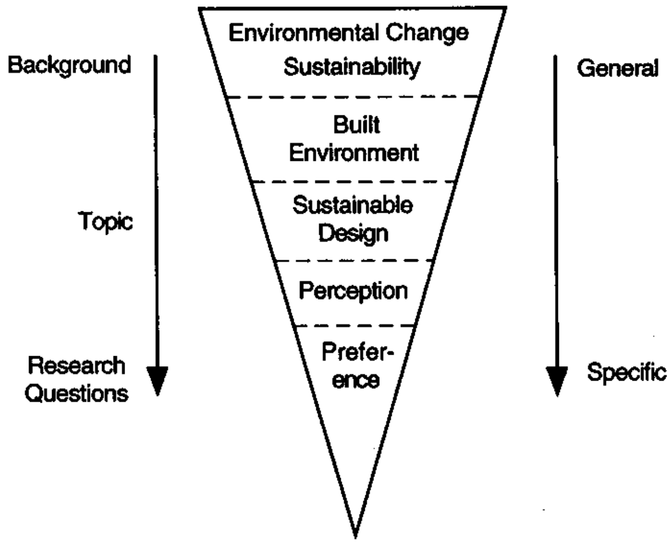


Figure 1. Composition of the thesis—from background to research questions.

design and data collection methods including sample and population, stimuli, variables and their instruments, treatments, and data collection procedure. Description of pilot tests that were conducted to check the stimuli and instruments is also included in this chapter. The research employs a set of photographs as stimuli to measure people's preference for sustainable design. Chapter 5 presents some criticisms of using photographs as a surrogate of the environment along with arguments against those criticisms. The data analysis methods are also discussed in this chapter.

Chapter 6 discusses the results of the data analyses and their interpretation. The chapter has six sections corresponding to the six research questions. In each section, results of the analyses are presented followed by discussion.

Finally, in Chapter 7, implications of the research are summarised. Based on the results of the data analysis, some recommendations to current sustainable design practices are made. The final chapter also includes a discussion of limitations of the research and of possible future research directions.

Chapter Two

ENVIRONMENTAL CHANGES AND THE IDEA OF SUSTAINABILITY

While this thesis deals with people's preferences for sustainable design, it may be useful to put the study into a larger context of environmental changes and the general idea of sustainability. To help readers fully recognise the gravity of environmental problems, this chapter briefly reviews the extent of global environmental changes, human involvement in these changes, and the evolution of the idea of sustainability developed to cope with the serious predicament of the environment.

Global Environmental Changes

Human ability to change and modify physical environments is apparent from ancient times (Kates et al., 1990). Human simply cannot live without changing the environment (Tellegen & Wolsink, 1998). Hunter-gatherers who used tools and fire were responsible for extinction of various animal and plant species (e.g., Flannery, 1994). Domestication of animals and rise of agriculture in early civilizations also modified ecosystems significantly through further loss of species, deforestation, and soil erosion (e.g., Ridley & Low, 1994; Simmons, 1997; Southwick, 1996). However, it is development of the industrial society that has transformed the global environment far more extensively. The use of fossil fuels, rapid growth of population, and resulting urbanisation have caused changes not only on the surface of the earth but also to fundamental flows of materials and energy in global ecosystems (Kates et al., 1990; Meyer, 1996). The last half of the 20th century, in particular, witnessed an unprecedented rate of global transformation in many aspects of the environment (e.g., Goudie, 2000; Tolba & El-Kohly, 1992; Young, Stern, & Druckman, 1992).

Because we are dependent on the wide range of services provided by the ecosystem, these changes in the environment pose serious threats to survival of many species including humans (Kibert, 1999). Although issues related to global environmental changes have been studied and published elsewhere (e.g., Goudie, 2000; Kates et al., 1990; Middleton, 1999; Tolba & El-Kohly, 1992), it may be worthwhile to review some of the notable environmental changes in the main components of the biosphere: air, water, land, and biota.

Air

Since the beginning of the Industrial Revolution, the carbon dioxide (CO_2) concentration in the atmosphere has increased by nearly 30 percent (Vitousek, Mooney, Lubchenco, & Melillo, 1997). There is a strong consensus among scientists that emission of greenhouse gases such as CO_2 has caused an increase of global atmospheric temperature (Intergovernmental Panel on Climate Change [IPCC], 1996; Mackenzie, 1998). The issues of global warming have been attracting serious public attention (e.g., Southwick, 1996). A large number of studies have reported significant increases in global temperature over the last century (e.g., Graham, 1995; Kates et al., 1990; Richards, 1993). Temperature rises have had significant and extensive impacts on the biosphere, including global climate change, a rapid increase of the sea level, desertification, and higher chance of severe natural disasters such as floods and drought (Goudie, 2000; Mackenzie, 1998).

Ozone layer destruction is another environmental issue that is a serious menace to living organisms and global ecosystems. A thin layer of ozone in the stratosphere acts as protection for life on earth from harmful ultraviolet radiation (Mackenzie, 1998). Emission of chlorofluorocarbons (CFCs), which have been used as refrigerants and aerosol propellants since the Second World War, has caused a thinning in the ozone layer and created "ozone holes" (Goudie, 2000). The depleted ozone layer has led to increased ultraviolet radiation on the earth's surface. Not only does this pose problems in human health but it also has deteriorating effects on productivity of terrestrial plants and aquatic life such as plankton (French, 1997; Middleton, 1999).

Water

Surface freshwater in the form of rivers, lakes, and wetlands is used not only for municipal, agricultural, industrial, and recreational purposes but also as a sink for wastes (Middleton, 1999). Annual water withdrawal by humans has more than trebled since 1950 and is still increasing (Goudie, 2000; Kates et al., 1990). In order to meet the demands for fresh water, people have been manipulating surface water in various ways including construction of dams and reservoirs (Vitousek et al., 1997). Alteration of water flow and accumulation of sediment as a result of dam construction often create considerable changes in rivers and their basins. The effects from the alteration include disruption in biological communities, downstream degradation, and local climate change (Goudie, 2000).

Where surface water is not available or is overused, people make use of groundwater. Depletion of aquifers is another environmental problem that has detrimental effects in the ecosystem. Because of long-term pumping of groundwater that exceeds the rate of aquifer recharge, the level of water-tables has been falling. This has brought about ground subsidence and seawater intrusion in coastal areas (Middleton, 1999; Goudie, 2000). The clearance of forests also has a significant negative influence on water retention in the ground, and is responsible for lowering ground water levels (Southwick, 1996).

Land

Humans have been modifying land to yield goods and services for the purpose of agriculture, industry, recreation, and transportation since the beginning of human habitation on the earth (Vitousek et al., 1997). Deforestation in the tropics is a major environmental issue in this regard. Logging, agriculture, cattle farming, and residential development are major forces that lead in many countries to the wholesale clearing of tropical forests (Middleton, 1999). Research has found that forest clearance since 1850 is more than 50 percent of the total clearance exercised by humans since the most recent end of glaciation (Kates et al., 1990).

As the forest ecosystem is vital to ecological stability of the earth, the impact of large-scale forest clearance on the environment is highly devastating and extensive (Mackenzie, 1998). Deforestation is likely to cause a loss of habitats for many species, resulting losses of biodiversity, increased soil erosion, more chance of flooding due to low water retention, lower ground water levels, increase of CO_2 in the atmosphere, and climate change on regional and global scales (Middleton, 1999; Southwick, 1996).

Soil degradation also endangers the earth's capacity to sustain life-forms. Soil filters and retains water, enables terrestrial plants to grow, recycles nutrients, and provides habitats for living organisms (Mackenzie, 1998). This important natural resource has suffered from soil erosion, desertification, and salinisation. Although soil degradation occurs by natural forces such as erosion from water and wind, it is human activities that have significantly sped up its process. Soil degradation now far exceeds the rate of soil formation (Mather & Chapman, 1995; Meyer, 1996). Inappropriate human land use such as extensive grazing, over-cultivation and over-exploitation has brought about soil erosion and desertification (Middleton, 1999). Salinisation, on the other hand, happens as a result of over-pumping of groundwater and the clearance of forests (Goudie, 2000).

Biota

The environmental changes discussed above are affecting plants, animals, and micro-organisms on the earth. It is now recognised that human pressures on natural ecosystems have been causing an unprecedented rate of extinction of species (Middleton, 1999). The extinction of species (or loss of biological diversity) itself is a natural process. However it is again human action and its effects that have accelerated the rate of extinction (Vitousek et al., 1997). The rate of species extinction has been 100 to 1,000 times faster than before the advent of human beings (Brown, Flavin, & Kane, 1996). Habitat destruction, harvesting, introduction of new species, and pollution are four major forces considered to be behind homogenisation of the biotic environment (Peters & Lovejoy, 1990).

Loss of biological diversity has various consequences. Less species diversity leads to a poor gene pool, which may result in higher vulnerability to a particular pest or disease (Mather & Chapman, 1995). Extinction of certain species can also upset the balance of many ecosystems by affecting food chains (Vitousek et al., 1997). Biodiversity also provides a large variety of potentially useful species for medical purposes (Gardner & Stern, 1996). Biological diversity is thus an important property for the long-term stability of the environment as a life-support system (Tolba & El-Kohly, 1992).

Human Impacts on the Environment

We are now living in a world dominated by human beings. The global environmental changes are largely anthropogenic in origin (Lubchenco, 1998; Young et al., 1992). People, consciously or unconsciously, modify the environment in their efforts to satisfy their needs and wants (Kates et al., 1990). It has been suggested that the human impact on the earth can be formulated in the following equation:

$$I = P \cdot A \cdot T$$

where I is impact on the environment, P is human population, A is affluence or per capita resource consumption, and T is technological efficiency (Ehrlich & Ehrlich, 1990). This conceptual formula provides relative measurement of environmental impact due to the change in the three factors.

The human population trend has been widely studied and well understood. Between 1960 and 2000, human population in the world more than doubled from 3 billion to 6 billion (Brown, Starke, Renner, & Halweil, 2000). According to a study by the United Nations (1999), another 3 billion will be added to the world population by 2050. This rate of population increase is phenomenal considering that it took the almost entire human history, roughly 2 million years, to reach the population of 1 billion (Goudie, 2000; Kates et al., 1990).

In contrast to a clear and simple definition of population, researchers do not agree as to what needs to be included in the definition of affluence or consumption relative to sustainability (Princen, 1999). In spite of the definition problem, studies convincingly demonstrate that per capita consumption is rising, especially in the developed countries (e.g., Kates, 2000; Wernick, 1996). A study in England, for instance, indicates that individual consumer expenditure doubled in the last four decades (Jackson & Marks, 1999). Another study estimates that resource use per person has nearly trebled on average between 1950 and 1990 (Ehrlich & Ehrlich, 1990).

The role of technological efficiency on the environment is even more difficult to assess. Originally, technology in this equation is supposed to reduce the impact on the environment (Ehrlich & Ehrlich, 1990). However, according to Commoner (1971), it is flawed technology rather than population or affluence that has caused environmental degradation. The effect of technology in the equation varies hugely between different scenarios depending on the assumption made (Olson, 1995).

Regardless of the ambiguities in the definitions of the IPAT equation, there is little doubt that human-induced changes to the whole ecosystem are enormous (Kates et al., 1990). If the above figures are applied to the equation (without counting the controversial effect of technology), human impact on the earth exhibited a four- to six-fold increase in the latter half of the twentieth century. Some might consider in this context that nature is resilient enough to be able to adapt to continuing human pressure on the environment. However, many of the above changes are completely irreversible, and researchers believe that the life-support systems of the ecosystem are in a critical condition (e.g., Lubchenco, 1998; Vitousek et al., 1997). A number of scientists believe that ever increasing human impacts on the earth have already exceeded the capacity of the earth to sustain its habitants at a reasonable standard of living (Westing, 1990). Thus, if humans societies are to survive and prosper along with the other species, we need to act immediately to resolve environmental problems and restore the life-support systems (e.g., Gorham, 1997; McIsaac & Brün, 1999).

The Idea of Sustainability

The notion of sustainability has emerged in response to growing concerns about the environmental degradation and their implications for our future (Corson, 1994). This idea has its origin in the discussion, which began in the 1960s, about increasing human population pressure and the earth's carrying capacity (Johnson, 1995). An early important study in this regard was *Limits to Growth*, commissioned by the Club of Rome (Meadows & Club of Rome, 1972). The study conducted by a group of researchers at the Massachusetts Institute of Technology forecasted that human population and production growth would reach their limits within one hundred years because of scarcity of food, resource depletion, and pollution (Meadows & Club of Rome, 1972). Although the study was criticised for its lack of scientific evidence, it is still significant that it made people aware of the unsustainable nature of human population and production trends at that time (Johnson, 1995; Tellegen & Wolsink, 1998).

The term "sustainable" began to draw widespread attention following the publication of *Our Common Future*, also known as the Brundtland report (WCED, 1987). While the limits-to-growth arguments emphasised that economic growth cannot continue without future environmental disasters, the idea of sustainability seeks ways to accommodate development while maintaining global life-support systems (Bartlett, 1997; Beder, 1996). The definition of *sustainable development*, according to the Brundtland report, is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43).

This concise and most often-quoted definition has been often criticised as containing internal contradiction between the finite natural system and continuing economic growth (Southwick, 1996). As Goodland (1995) explains in the following, it is conceivable that the idea of growth is unsustainable in essence:

> The scale of the human economy is a function of throughput—the flow of material and energy from the sources of the environment, used by the human economy, and then returned to environmental sinks as waste. Throughput growth is a function of population growth and consumption. Throughput growth translates into increased rates of resource extraction and population (use of sources and links). The scale of throughput has exceeded environmental capacities: That is the definition of unsustainability. (p. 13)

However, the concept of sustainable development is viable if we consider the focus of discussion as a qualitative change within a system (development) rather than physical expansion of economic systems (growth) (Daly & Cobb, 1994). It can be argued, in this sense, that sustainability is an attempt to overcome the dilemma between the physical limits of ecosystems and ever increasing human activities.

Despite the many attempts to define sustainable development and sustainability (e.g., Goodland, 1995; Jacobs, 1991; WCED, 1987; World Wildlife Fund for Nature [WWF], 1993), their definitions are still a subject of debate (e.g., Farrell & Hart, 1998; Mazmanian & Kraft, 1999). It is partly because sustainability is a broad and complex concept involving ecological, environmental, economic, technological, social, cultural, ethical, and political dimensions (Corson, 1994). For example, a sustainability definition proposed by economists differs markedly from that put forward by ecologists (e.g., Goodland, 1995). However, the lack of a universally agreed definition should not discredit the significance of the idea of sustainability (Jepson, 2001). This concept is more a way of thinking as to how we relate to the natural environment rather than a detailed scheme (Johnson, 1995). In fact, "its potential to engage people's hope, imagination, and sense of responsibility may depend more on strategic use of ambiguity than on conceptual precision and clarity" (Hempel, 1999, p. 44).

Both ecologists and economists concur that the maintenance of life-support systems is a fundamental principle of sustainability (e.g., Beder, 1996; Goodland, 1995; Jacobs, 1991; Southwick, 1996). The environment provides us with air, water, food, and other services essential for survival and well-being of the species on the earth. Assimilation of waste by the environment is also a part of life-support functions (Goodland, 1995). The term "natural capital" is often used to refer to the stock of environmental assets that provide the fundamental life-support services (e.g., Goodland, 1995; Harte, 1995). The principle of sustainability, then, can be understood as maintenance of the natural capital. This means that we need to live on "interest" from the natural capital and to take care of the capital so that it keeps yielding interest (Southwick, 1996).

Another important aspect of sustainability, closely related to the above, is "intergenerational equity" (e.g., Daily & Ehrlich, 1992; Jacobs, 1991). As can be seen in the definition in the Brundtland report, the idea of sustainability concerns the long-term functioning of the environment. However, our current population growth and consumption are actually harming future generations by depleting natural capital at an alarming rate. While environmental resources have been sustaining humans and other species for the last million years, they are rapidly approaching a dangerous level (Goodland, 1995). It is the responsibility of the current generation to manage renewable resources and preserve nonrenewable resources. Thus the idea of sustainability involves our moral obligation to restore and maintain life-support systems for future generations as well as for other species (Kibert, 1999).

Means to Improve Sustainability

In our societies' approaches to sustainability, it is clear that humans need to act immediately and effectively to change the way that environmental assets are currently exploited. Until recently, however, based on the notion of "pristine and untouched" nature, human interventions to the environment were often regarded as unnatural and undesirable (McKibben, 1989). It is argued that "modern" human-induced transformations to the earth have been much more profound and rapid than those originated by most other species (Lubchenco, 1998). However, all human interventions to the environment have not necessarily resulted in degradation of the environment (Kates et al., 1990). Some native American settlements (Nabhan, 1997) and Asian wet-rice ecosystem (Dubos, 1980), for instance, have contributed greatly to richer biodiversity and resilience of ecosystems. It is also known that in many areas of the world, people have successfully managed common resources for thousands of years (Ostrom, Burger, Field, Norgaard, & Policansky, 1999). A recent trend of environmentalism has been a shift from preservation to restoration in which people play an active role in the management of the environment (Turner, 1994). Therefore, in this human-dominated world, it is our task to actively participate in the process of global ecosystem restoration (Gorham, 1997; McIsaac & Brün, 1999).

There is a broad range of possible ways to improve sustainability. What is at stake in today's environment is the biophysical quality of the environment such as air, water, soil, and other natural resources. However, environmental problems "are *not* solely technical problems, requiring simply engineering, physics, and chemistry for their solution" (Oskamp, 2000; p. 375, original emphasis). Indeed, when discussing the issues of sustainability, it is implicitly acknowledged that it encompasses human life, and its success depends on the way humans behave (Clark, 1994). Thus, means to improve sustainability span from the one dependent on technology to the one employing social science. This section briefly reviews a few commonly adopted ways to achieve sustainability relevant to this thesis.

Science and technology

One might think that a breakthrough in science and technology in the near future will save us from the predicament of today's environment. If technological development can dramatically reduce the T factor in the IPAT formula, then we may be able to achieve sustainability. In fact, a group of researchers estimated a scenario of "technological transformation" in which fossil-fuel-based energy is replaced by renewable energy, and all the waste is reclaimed as resources for other processes (Meadows, Meadows, & Randers, 1992). Under this scenario, they calculated that in 50 years the environmental impact by technology can be reduced to 0.2 percent of the current level (Meadows et al., 1992). However, most considered the scenario unrealistic and economically unfeasible (Olson, 1995).

Technology does improve the efficiency in resource use to some extent. It has been pointed out, however, that current science and technology cannot deal with the complexity of the natural systems and phenomena (Healy, 1995). Human-made systems are a very poor substitute for natural systems (e.g., Goodland, 1995). The failure of a US$200 million project *Biosphere II*, an attempt to replicate a livable ecosystem completely isolated from the biosphere of the earth (for only eight people), clearly illustrates that modern technologies cannot replace natural ecosystems (Thayer, 1994).

In addition, technology is not effective in solving common-pool resource problems, also known as "tragedy of the commons" (Hardin, 1968; Ostrom et al., 1999). The common-pool resource problem is depletion of a natural resource by many self-interested individuals who have unrestricted access to the resource (Gardner & Stern, 1996). Although, technology can increase efficiency in resource usage and help monitor available resources, a solution for the problem, in essence, depends on cooperation of appropriate parties relying on a particular resource (Ostrom et al., 1999). As these examples demonstrate, we cannot expect that science and technology alone can resolve all the environmental problems.

Behaviour modification

Another way to improve sustainability is to change environmentally relevant behaviours, which can reduce the A (affluence) factor in the IPAT formula. Although behaviour modification may also be applied to family planning to reduce the P (population) factor, the discussion here focuses on behaviours that have direct impacts on the environment such as recycling, reducing energy use, and use of public transportation. To modify those behaviours, researchers from the behaviour modification school of thought have examined the effects of various intervention methods such as education, persuasive communications, incentives and disincentives, facilitating behaviour changes, information feedback, and community support (e.g., De Young, 1993; Geller, 1992; McKenzie-Mohr, 2000). It is not the purpose of this thesis to review those efforts to induce behaviour changes. However, it seems worthwhile to examine one commonly held belief. It is often asserted that the best measure to solve environmental problems is to alter people's egocentric and anthropocentric attitudes for the common good (Ridley & Low, 1994). It has been claimed that what is currently valued in our society—the dominant social paradigm (DSP)—is not consistent with the tenet of sustainability. Accordingly, fundamental restructuring of our value orientation is considered essential to make our society sustainable (e.g., Corson, 1994; Milbrath, 1994).

This argument, however, is seriously questioned by a comprehensive study of Gardner and Stern (1996). These authors argued that the many commonly held notions about human attitudes and values as a source of environmental problems are propositions without empirical evidence (Gardner & Stern, 1996). Firstly, they claim that it is mostly organisational rather than individual behaviours that are responsible for today's environmental degradation. For example, households account for about one third of the total energy consumption in the US, and only five percent of solid waste by weight (Stern & Gardner, 1981). Secondly, these researchers pointed out that countries such as India and China, where religious beliefs include proenvironmental attitudes, have not shown a good history of environmental protection. Thirdly, they argued that studies have demonstrated rather weak links between environmental attitudes and environmentally responsible behaviours despite that people are highly concerned with the current condition of the environment (e.g., Hines, Hungerford, & Tomera, 1986/87; Scott & Willits, 1994).

According to the theory of planned behaviour (TPB), it is behavioural *intention* that is a proximal cause of actual behaviour (Ajzen & Fishbein, 1980). Although a causal relationship exists between attitudes and behavioural intention, there are often high barriers between intention and actual behaviours (Tellegen & Wolsink, 1998). For instance, even if one has the intention to use public transportation to commute, often no practical option is available other than to use a private car. What is suggested here is that identifying and rearranging situational factors are a key to behaviour modification (Stern, 2000).

Another behaviour modification approach, strict regulation by authorities, which was successful in resolving environmental pollutions, is considered not very effective to achieve sustainability (e.g., John, 1994). Environmental pollution, on the one hand, has been caused by a limited number of polluters (point sources), which can be easily identified and monitored. On the other hand, current environmental problems are results of a vast number of people's behaviours such as use of automobiles by commuters and use of chemicals by farmers (non-point sources), which are rather difficult to regulate (John, 1994; Lyle, 1994).

It is clear that we need to change our behaviour patterns ultimately in order to achieve a sustainable future (e.g., De Young, 1993). However, this transition may take a very long time. Our world views are absorbed early in childhood. They are constantly reinforced by the dominant pattern of sociocultural activity (Milbrath, 1989). Thus, even 40 years after the publication of *Silent Spring* (Carson, 1963), which raised awareness toward the gravity of environmental problems, people's behaviour patterns are still leading to severe impacts on the environment (e.g., Ehrlich & Ehrlich, 1990; Jackson & Marks, 1999). It appears that the behaviour modification approach to sustainability needs to overcome many barriers to accomplish its goal.

Design of the built environment

It is possible to reduce environmental impacts dramatically by changing construction and design of the *built environment*. This way of improving sustainability involves both A (affluence) and T (technology) factors in the IPAT formula. Due to the explosion of human population, the built environment has also been expanding its size relative to the whole environment. The built environment, the environment we construct and manage for various purposes, has "input" and "output." It requires a considerable amount of material and energy, the input, for its construction and maintenance (Kibert, 1999). Its output includes carbon dioxide, sewage, and solid waste during its construction, operation, and demolition phases (B. Edwards, 2001; Van der Ryn, 2000). Since the ecosystem has limits in terms of resource availability and the sink function, a basic strategy of the design of the built environment for sustainability is to reduce the amount of both the input and the output.

Various ways to achieve the above goal have been developed, tested, and applied to actual settings. Recycling and reusing are highly effective in reducing the amount of the input resources and impact of the output on the environment (e.g., McDonough, 1992; Lyle, 1994). Incorporating the power of nature such as sun, wind, and biological processes also helps diminish the use of fossil fuels, which in turn reduces both resource use and waste emission (Strong, 1999). Energy efficient and energy saving systems have the similar effect. Biological processes have another benefit such as assimilating waste materials and purifying water and air (Lyle, 1994). Using materials which require less energy for manufacturing and recycling is also an effective approach in this regard (Malin, 1999). Furthermore, longer life of the built environment results in reducing both the amount of necessary resources and environmental impact (Wines, 2000). Thus, by employing various technologically efficient and ecologically sound measures in the planning and design of the built environment, it is possible to contribute greatly to the maintenance of the environment and its life-support services (e.g., Kibert, 1999).

This thesis explores the issues of sustainability in the designed built environment. By introducing this idea, the thesis seeks to integrate the biophysical and sociocultural dimensions of sustainability. The next chapter discusses the idea of built environment and its impacts on the ecosystem. After the introduction of the concept of ***sustainable design***, i.e., the attempts to promote sustainability through design of the built environment, the next chapter examines the sociocultural aspect of sustainable design to explore the possibility of creating more effective sustainable design.

Chapter Three

SUSTAINABLE DESIGN

The Built Environment

This thesis is interested in sustainability issues in the built environment. The built environment encompasses all human-built structures and human-managed landscapes. The biophysical environment of the earth has been modified by human activities for the purposes of habitation, production of goods, commerce, transportation, communication, and recreation (Smith, Whitelegg, & Williams, 1998). The built environment has been created as a result of these human interventions. The general purpose of the built environment is to provide shelter, comfort, security, hygiene, convenience, and amenity to people (e.g., Rapoport, 1994; Ross et al., 1994). Examples of the built environment include buildings, roads, bridges, billboards, water supply and drainage, power-transmission line, parks, gardens, cultivated land, urban forests, landfill, windmills, reservoirs, canals, and many more.

The built environment has been developed over time through human endeavour to embody human needs and wants (Rapoport, 1994; Ross et al., 1994). Accordingly, various forces have operated in the process of creating the built environment. For example, the high and luminous inner space of a Gothic cathedral, which was an aspiration of religious societies in Europe during the Middle Ages, hinged on construction technologies available at that time. Construction of a nuclear power plant, which is promoted by politics and enabled by modern technology, often meets fierce opposition from a local society. As these examples imply, sociocultural, economic, technological, and political factors affect the formation of the built environment either as constraints or as thrust (Collier, 1995; Smith et al., 1998).

Figure 2 is a conceptual diagram illustrating dimensions involved in the construction of the built environment. As mentioned above, human interventions backed up by needs and wants

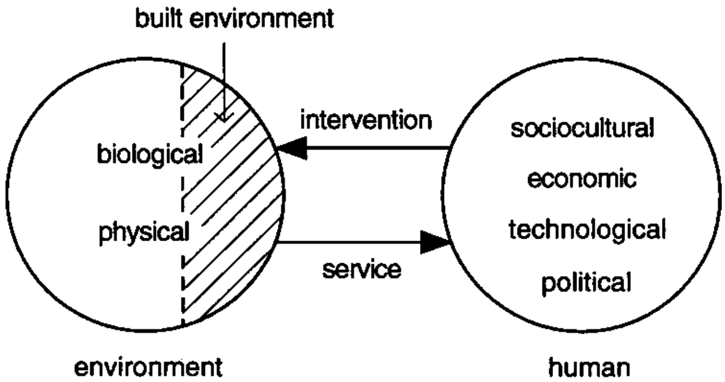


Figure 2. Dimensions involved in the construction of the built environment.

of societies shape the built environment. Humans, on the other hand, receive diverse services from the environment. The environment is composed of two dimensions: biological and physical (Tellegen & Wolsink, 1998; Yeang, 1995). From an ecological point of view, the ecosystem is divided into abiotic (nonliving) and biotic (living) of which humans are a part (Southwick, 1996). However, in the diagram, the human is considered independent from the environment in order to illustrate human influences on the environment. The human side has four dimensions: sociocultural, economic, technological, and political. Among them, the current study mainly focuses on the sociocultural aspect of the built environment. In the course of exploration, the study occasionally touches on the role of technology in the built environment. Although economics and politics are important constituents in the formation of the built environment, these dimensions will not be discussed in this study.

Sustainability and the Built Environment

The built environment is a major consumer of energy and resources. The built environment consumes 30 to 40 percent of global energy production and 40 percent of extracted resources (Kibert, 1999). About half of total chlorofluorocarbons (CFC) emission is produced in the building industry, mainly from air conditioning (Moughtin, 1996). Solid waste from construction and demolition accounts for 40 percent of landfill in Australia (Environment Australia, 1998). Because of the enormous volume and intensity of energy and resource use, the built environment exerts immense pressure on the whole ecosystems (Smith et al., 1998). Comprehensive and often devastating impacts of the built environment on natural systems are described by Kibert (1999):

> Nature provides all the goods and material needed to create the fabric and working components; the land on which buildings and infrastructure are located; the fuel to power the construction and run the resulting structures; the water for the occupants; and the mechanisms for absorbing, assimilating, and processing waste. . . . The actual creation of the built environment has many negative impacts on the natural systems that are in fact so crucial to its existence: destruction of plants and wildlife habitat, solid waste generation, non-point source pollution, release of toxic materials, alternation of natural drainage systems, and water and air pollution. (p. 2)

It seems quite clear that the misuse and mismanagement of the built environment are heavily responsible for today's environmental problems. From an opposite point of view, it is also the case that the built environment provides abundant opportunities to promote global sustainability. By reorganising the way the built environment is constructed and used, it is possible to improve sustainability to a considerable degree.

Regarding the relationship between sustainability and the built environment, it is important to distinguish between sustainability *of* the built environment and sustainability *in* the built environment. Sustainability *of* the built environment is concerned with the extent to which a certain built environment is contributing to sustainability with its physical and technological functions and organisation (Rapoport, 1994; Ross et al., 1994). Sustainability *in* the built environment, on the other hand, embraces people who use or live in the built environment (Ross et al., 1994). Sustainability in the built environment, thus, can be achieved as an outcome of the interaction between the physical environment and people.

These two ideas can be quite different. For example, two houses in the same site, identical in plan, construction method, material, and technology, can differ greatly in their energy usage if the occupants differ in the way they behave in the houses (Rapoport, 1994). As this simple example illustrates, the idea of sustainability *of* the built environment deals with only a part of the overall sustainability to be achieved in a real-life setting. Sustainability *in* the built environment, which encompasses not just the biophysical aspect but also the sociocultural aspect of sustainability, therefore needs to be examined.

The integration of physical environmental issues with people and their society attracts support from other authors. Criticising poor management of ecosystems in conventional resource management practices, Berkes and Folke (1998) stressed the significance of linking social and ecological systems. Hempel (1999) also proposed the idea of a "sustainable community" in which sustainability issues are identified, assessed, and dealt with in the context of a local community and its habitants. This movement is an important step toward sustainability, because, in ecology, people as well as the built environment are part of the whole ecosystem (Yeang, 1995).

Sustainable Design

In this thesis, the term *sustainable design* is employed to refer to the means and ways in which the built environment is designed to improve sustainability by resolving or alleviating a particular set of environmental problems. In terms of conventional fields of study, sustainable design encompasses architecture, landscape architecture, urban design and planning, and civil engineering.

There have been many ideas and attempts of sustainable design. Designers, planners, and researchers have been discussing, examining, and implementing such ideas as "sustainable design" (Crosbie, 1994; McDonough, 1992), "sustainable landscape" (Thayer, 1989, 1994), "green architecture" (B. Edwards, 2001; Vale & Vale, 1991; Wines, 2000), "ecological design" (Mozingo, 1997; Todd & Todd, 1994; Van der Ryn & Cowan, 1996; Yeang, 1999), "regenerative design" (Lyle, 1994), and "ecological planning" (Alario, 2000; Steiner, Young, & Zube, 1988). These ideas seem to concur in their intention to incorporate the concept of sustainability into design principles for architectural and other built environments. However, even in the field of the built environment, there are a plenty of environmental issues and a variety of measures to approach them. Accordingly, sustainable design can differ greatly in its target problems and operational mechanisms. It is possible to distinguish three types of sustainable design depending on its measure to approach to sustainability: physical, ecological, and social sustainable design. The following sections review these three approaches.

Physical sustainable design

In architecture and civil engineering, final products are typically physical structures such as buildings, roads, and bridges. One approach to sustainability often taken in these areas deals with energy and material issues associated with the physical built environment. Important objectives in this type of sustainable design are conservation of energy (energy use reduction and high energy efficiency), use of less material resources, and less impact on the environment (Anink et al., 1996). In the case of building design and construction, actual practices include use of solar energy (passively or actively) and other regenerative energy, installation of good insulation, natural ventilation, use of energy efficient apparatus, recirculation of "grey" water, material recycling and reusing, long lasting structure, and use of alternative construction materials such as clay and straw (e.g., Adams & Elizabeth, 2000; Mobbs, 1998; Vale & Vale, 1991; Wines, 2000). Life cycle assessment (LCA), which evaluates a certain structure by its energy and resource use in the processes of material production, construction, maintenance, and demolition, is a recent integrative method in this approach (e.g., Lawson, 1996; Malin, 1999).

Although these technology-oriented methods are effective to some extent to improve sustainability of the built environment, a strictly physical design approach is often regarded as insufficient because of its exclusion of the biological and sociocultural components of the built environment (e.g., Yeang, 1995). The next sections cover more inclusive approaches to sustainable design.

Ecological sustainable design

As explained earlier in this chapter, the environment has two components: biological (biotic) and physical (abiotic). These two systems are considered separate conceptually, but flows of energy and material unite the two realms closely. Since the built environment consists of both systems, many environmental designers have found it essential to incorporate the biological system into constituents of sustainable design (e.g., McHarg, 1969; Lyle, 1994; Todd & Todd, 1994; Van der Ryn & Cowan, 1996; Yeang, 1995). The term *ecology* is defined as the study of interaction between organisms (including humans) and their nonliving environment (Diesendorf & Hamilton, 1997). Thus, in ecological sustainable design, the interaction between ecological processes and built environments is an important design issue to be considered (e.g., Yeang, 1995).

Ecological sustainable design appears to have two slightly different branches: one originated from landscape ecology, and the other developed from physical sustainable design. *Landscape ecology*, which was coined by the German geographer Troll in 1963, integrates a spatial concept of geography with ecology (Hersperger, 1994). This field of study is applied to environmental design and planning to solve various environmental problems (e.g., Galatowitsch, 1998; Golley & Bellot, 1991). An early and influential application of landscape ecology to design and planning was *Design with Nature* by McHarg (1969). Thayer (1994) describes two principles of ecological sustainable design: "First, a reduction in the *rates* of consumption of energy, water, food, and other resources not to exceed the rates at which they can be renewed and regenerated, and second, a closing *resource loops* at all possible points" (p. 238, original emphasis). Strategies for ecological sustainable design include wise use of benefits from nature (e.g., using natural contours to guide flows, using predator instead of chemicals, and using plants to control microclimate, etc.), conservation and regeneration of various resources, composting, monitoring environmental changes, and long-term management (e.g., Grant, Manuel, & Joudrey, 1996; Lyle, 1994; Todd & Todd, 1994).

The other branch of ecological sustainable design can be found in the field of architecture. *Ecological design*, according to Van der Ryn and Cowan (1996), is defined as a "marriage of nature and technology." These authors advocate the importance of integration of physical design and natural processes. Their approach employs both physical (technological) and ecological means to realise sustainable design. Other architects such as B. Edwards (2001), McDonough (1995), Wines (2000), and Yeang (1995) also exhibit their strong support for ecological sustainable design. Yeang (1995), for instance, stated the importance of ecological sustainable design as follows:

> Traditionally, the architect has been responsible for the assembly of materials at the site, the construction of the building, and often maintenance and renovation of the building after it has been completed. However, an ecological design approach would require that the designer be concerned not only with these traditional responsibilities but also with the ecological interactions between the designed system and its environment over its entire physical life cycle. (pp. 17-18)

It is notable that physical sustainable design discussed before works within the boundary of the "traditional responsibilities" Yeang suggested in the above. In this sense, ecological sustainable design can be thought to encompass physical sustainable design.

Currently, it appears that ecological design is a "main stream" of sustainable design. The design and research literature reports many recent design attempts following this principle in architecture (e.g., Briffet, 2001; Girardet, Dunster, & Johnston, 2001; Yeang, 1999) and landscape and planning (e.g., Alario, 2000; Gonzalez, 1998; Pezzoli, 1998). Remarkable advances have been achieved thanks to the above two approaches to sustainability (Kellert, 1999). However, in order to advance sustainable design further, there is another level to be achieved. The next section addresses social sustainable design.

Social sustainable design

The emphases of the previous two approaches are the physical or biological aspects of the environment. Both types of design are concerned with the environment rather than people who are designing, constructing, using, and taking care of the environment. For instance, the definition of ecological design by Van der Ryn and Cowan (1996) as a "marriage of nature and technology" seems to exclude human involvement from design considerations. McHarg (1969) criticised aesthetic conventions of landscape architecture as "occult and esoteric pretensions and an intrinsic obscurantism" (p. 165). Mozingo (1997) pointed out that McHarg's perspective, which negates the aesthetics of design, seems to consider that people's perceptions are irrelevant to landscape design. As Thayer (1994) discussed, functionalistic approaches to environmental and landscape design are used by landscape architects other than McHarg (e.g., Hall, 1991). In addition, recent review articles in urban planning (Grant et al., 1996; Hersperger, 1994; Selman, 1995; Steiner et al., 1988) focus on the importance of ecological issues, but fail to address sociocultural issues of sustainable design. Although these authors acknowledge the importance of such dimensions as public involvement, recognition of the social aspect of sustainable design appears almost nonexistent.

As these examples suggest, sustainable design often relies on ecological, physical, and technical solutions to the exclusion of sociocultural solutions. As a result, it seems that there is a conflict between sustainable design and wants of a society. Rapoport (1994) explained this conflict as follows:

> From an EBS perspective design is for people and their wants (as well as needs). Not only do wants need to be considered, but taken as primary. This is because the purpose of built environments is to be supportive of human wants (and needs). Yet many wants which result in particular built environments (as cultural landscapes/systems of settings) may conflict with those based on criteria for sustainability. . . . (p. 4)

As Rapoport implied, sustainable design is not closely associated with people's wants and needs, although its ultimate aim is to support human life. The purpose of social sustainable design is to bridge the gap between sustainable design and wants of people.

As shown earlier in Figure 2, the built environment is a result of human interventions to the environment. The way we create the built environment is heavily influenced by sociocultural factors such as life style, cultural preferences, value orientation, future images, and world views (e.g., Olson, 1995; Rapoport, 1994; Tuan, 1974). It can be argued in this sense that the sociocultural dimension is one of the driving forces of human interventions in and on the built environment. The idea of sustainability is concerned with maintaining not only an ecological system but also a social system (e.g., Rapport et al., 1998; Thayer, 1994; Thering & Doble, 2000). As Kay and Schneider (1994) commented, what we need to manage is not the ecological system itself but human interaction with the system. Thus, in order to promote sustainability further, it is highly important to develop sustainable design that works in cooperation with people. The importance of the social aspect of sustainable design is further highlighted when we consider people's concern with their surroundings and their power to influence the formation of the built environment (e.g., Hudspeth, 1986).

The distinction between sustainability *of* the environment and sustainability *in* the environment has been discussed earlier in this chapter. It can be argued that physical and ecological sustainable designs are interested in sustainability *of* the environment. On the other hand, social sustainable design aims to achieve sustainability *in* the environment. It has to be emphasised that social sustainable design is inclusive of physical and ecological sustainable designs. It aims to improve physical and ecological sustainable designs by incorporating a sociocultural dimension.

Then what is social sustainable design like? In this thesis, *social sustainable design* is characterised as design attempts that focus on its interaction with people as well as its physical and ecological qualities in order to work toward achieving sustainability. In social sustainable design, people are not apart from but a part of the process toward sustainability (Rapport et al., 1998). More specifically, social sustainable design may inform people of its intention and functions, attract people's attention and support, comply with people's cultural expectation, be pleasing to human senses, be easy to operate, and remind people of environmental resources nearby (e.g., Gobster, 1994; Mozingo, 1997; Scott, 1998; Thayer, 1994; Van der Ryn, 2000). This is not an exhaustive list. There may be many other ways to achieve social sustainable design. But in essence, the aim of social sustainable design is to engage the everyday users through physical design in the process toward sustainability. It is thus the most comprehensive sustainable design including physical, ecological, and sociocultural approaches and methods.

In the fields of the built environment, little research appears to acknowledge the significance of social sustainable design except for a few studies conducted by such researchers as Gobster (1994, 1999), Mozingo (1997), Nassauer (1992, 1993, 1995b), and Thayer (1989, 1994). However, the sociocultural dimension does attract attention in some other disciplines related to sustainability. They include studies of human population, resource consumption, and food production (e.g., Jackson & Marks, 1999; Ostrom et al., 1999; Schipper, 1996). However, when people and their societies are discussed in the context of sustainability, the argument is mostly about global issues such as population, intergenerational and intragenerational equity, poverty, and resource depletion, which have little direct significance for the design of the built environment (Rapoport, 1994).

Obstacles to Social Sustainable Design

Despite its important contribution to sustainability, social sustainable design has not received much attention from environmental designers. Empirical research in this topic is also very limited. Why has so little been done with respect to social sustainable design? What makes inclusion of the sociocultural dimension so difficult? In this section, the thesis discusses an obstacle which prevents social sustainable design from propagating.

The present study argues that one major obstacle to the promotion of social sustainable design is disregard for the importance of the *visual aspect* of sustainable design among designers, planners, and policy makers. It is known that the visual quality of the environment has a central role in human experience of the environment (e.g., Nasar, 1998). Many studies to date have advocated the importance of the visual aspect of the environment. For instance, works by Lynch (1960) and Boulding (1956), which acknowledged the significance of images, are classic examples. Gibson, who developed the important concept of *affordance*, i.e., what a perceived object or scene has to offer to the perceiver, described the environment as an arrangement of *surfaces* that separate substances from the medium of the air (Gibson, 1979; Heft, 1997). In his theory, it is perception of surfaces rather than that of substance that provides affordance (Gibson, 1979).

Researchers in EBS have also examined the effects of visual environments on people's behaviours and their psychological well-being. Several studies have found that a view of nature can have restorative effects, satisfaction with neighbourhood, and a sense of well-being (e.g., Hartig, Mang, & Evans, 1991; Herzog & Bosley, 1992; R. Kaplan, 2001; Ulrich, Simmons, Losito, Fiorito, Miles, & Zelson, 1991). Another line of study has discovered that the visual environment has some impacts on vandalism and crime prevention (e.g., Kuo, Bacaicoa, & Sullivan, 1998; Rich, 1993). Wayfinding behaviours are also dependent on visual-spatial information such as landmarks and paths (e.g., Devlin & Bernstein, 1995; Heath, 1988). Other than the area of EBS, appearance or style of products is obviously a central issue in consumer behaviour (Sancar, 1985). As Tuan (1989) describes, we "respond to things around us and to each other because of how they *appear*" (p. 235, original emphasis). These instances clearly demonstrate that the visual aspect of the environment heavily influences people's daily behaviours and decisions.

In spite of the above evidence, people have been reluctant to give much weight to "appearances" in comparison to "substance" (Maguire, Foote, & Vespe, 1997; Tuan, 1989). Although visual information constitutes a major part of our perception of the environment (Urlich, 1983), appearance is often associated with negative adjectives such as superficial, surface, and cosmetic. Tuan (1989) explains our tendency to think light of the significance of the visual aspect in a broader context:

> At base are certain questions, addressed by philosophers since antiquity, concerning the relationship between surface and that which lies beyond or behind it, between appearance and underlying reality, between sensory appreciation and intellectual understanding. In deliberating these questions, the greater prestige of "depth" is assumed (p. 233, original emphasis).

This attitude to downplay visual phenomena seems more apparent among professional designers, scientists, and policy makers. As Thayer (1989) blamed, for instance, there is a widely held notion that landscape architecture should transcend visual aspects to address ecological issues. Those designers often presume that "the ecological value of a landscape will speak for itself" (Mozingo, 1997, p. 507). Sancar (1985) also criticised that visual and aesthetic issues are deemed to be in direct conflict with other important issues in planning such as economy, politics, and ecology. In addition, Maguire et al. (1997) have pointed out that aesthetic issues are entirely absent from recent important documents and declarations regarding planning for sustainability. Comparing legislation passed in the 1960s including the US National Environmental Policy Act (NEPA) and that in the 1980s and 1990s, Maguire and her colleagues argued that the focus of environmental movements have shifted from aesthetics and heritage conservation to science and resource management.

As a result of the indifference to the visual aspect of sustainable design among designers, sustainable design is often very difficult to identify. Some types of sustainable design such as passive solar design, constructed wetland, and buildings incorporating sustainable technologies are quite hard to recognise for the public. Especially, in ecological sustainable design, its appearance often does not tell what is happening underneath (Nassauer, 1992). Without any visual cues, ordinary people may simply neglect sustainable design, or perceive it as being uninteresting or ugly. Thus, it can be argued that many examples of sustainable design operate outside the realm of a broader social interest (Mozingo, 1997). In this situation where sustainable design is illegible or unnoticeable, the positive engagement of people in the process of sustainability is unlikely to happen. Whether design features leading to sustainability are recognisable or not has a profound consequence in the promotion of sustainable design. Consideration of the visual aspect of sustainable design is, therefore, essential to motivate public support for expansion and replication of sustainable design (Mozingo, 1997).

Figure 3 is a conceptual diagram summarising the asymmetrical relationship in sustainable design discussed in this chapter. In many cases, designers of sustainable design are concerned with the physical and biological features of the environment without much attention to its appearance. However, the perception of lay people, who may not have extensive knowledge as to how sustainable design works, may depend on the visual aspect of sustainable design—whether or not it *looks* sustainable. Because of this discrepancy, sustainable design is often inconspicuous, invisible, or even misleading for lay users (e.g., Eaton, 1997; Nassauer, 1992). The lack of attention to the visual aspect of sustainable design thus can be

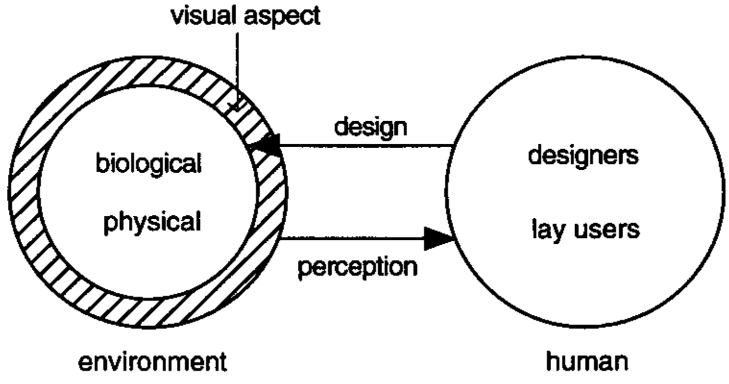


Figure 3. Asymmetrical relationship between the biophysical and visual aspect in sustainable design.

tantamount to neglecting involvement of people, who are an important and integral part of sustainability (Mozingo, 1997).

Focusing on the visual aspect for its own sake, however, may not be very fruitful. It can be argued that the significance of the visual aspect lies not in itself but in its function to bridge the built environment and people. Rapoport (1982) has indicated that people react to an environment in terms of the meanings it has for them. Thus, it is important that the visual aspect of sustainable design is recognisable and has some meaning to the public. Some professional designers, however, tend to be interested in pursuing their personal expression in the visual aspect of the environment without considering the aesthetic needs of clients (Newman, 1972). Appleyard (1979) criticised designers for their failure to conceptualise the environment as a web of social meanings. Empirical research has also demonstrated that professional designers and lay people often differ considerably in their preferences for different building designs (e.g., Devlin & Nasar, 1989). Thus the esoteric and elitist vocabulary environmental designers sometimes use to communicate within their society is similar to appearance of physical and ecological sustainable design in that neither of them convey intelligible meanings to the lay public.

It seems worthwhile in this regard to compare the environment with language. Lynch (1971) once described the environment as "an enormous communications device" (p. 384). Visual features of the environment, in this sense, are comparable to a vocabulary of language. Establishing a link between sustainable design and people is equivalent to furnishing the visual aspect of sustainable design with some meanings communicable to the public. Rapoport (1982) described that form acquires social meaning through "repeated use" within a society. Since sustainable design is rather new, it lacks reiteration that is essential for the construction of social meaning. Thus if a bridge is to be built between sustainable design and the public, sustainable design has to employ signs that have been used repeatedly in a society and already carry socially recognisable meaning (Nassauer, 1992). In this sense, designers who just focus on technological or ecological functions as well as those who try to avoid the conventional vocabulary of the environment (while pursuing novel expressions) fail to seize the opportunity to make sustainable design socially recognisable (Mozingo, 1997).

In conclusion, the research literature suggests that sustainable design may be quite effective when it takes the physical, ecological, and social aspects of sustainability into account. So far, physical and ecological approaches to sustainable design have been developed and constructed. However, sustainable design is quite often far from people's interests and the wants of a society (Mozingo, 1997; Rapoport, 1994). If a certain sustainable design engages people's interest, and thus attracts their support, it will have a better chance to be used widely in the society. Thus, in order to improve the effectiveness of sustainable design, social sustainable design, which involves people and their community in the process of sustainability, needs to be developed. It has been suggested that one of the obstacles of social sustainable design is designers' indifference to the visual aspect of sustainable design. Due to the lack of attention to the visual aspect, sustainable design often becomes something people simply do not notice (Nassauer, 1992). To achieve social sustainable design, designers have to pay close attention to its visual aspect to bridge sustainable design and people.

This chapter has suggested the importance the visual aspect in the sociocultural dimensions of sustainable design. Based on this recognition, the next chapter of the thesis discusses the idea of *environmental perception*. Then, as a tool to investigate the sociocultural aspect of sustainable design, the concept of *environmental preference* is examined.

Chapter Four

ENVIRONMENTAL PREFERENCE FOR SUSTAINABLE DESIGN

Environmental Perception

In the previous chapter, the thesis pointed out that the visual aspect of sustainable design needs to be addressed in order to deal with the sociocultural aspect of the environment and to bridge a gap between sustainable design and people. As shown earlier in Figure 2, the visual aspect is one property of the environment, which exists independently from a person who experiences the environment. The way individuals see the visual aspect of the environment is different from one person to another, and from one time to another (Ittelson, 1978). What matters in this thesis is not the visual aspect per se, but the way people *perceive* the environment. In order to address this relation between people and the visual aspect of the environment, the thesis introduces the idea of *environmental perception.*

The scope of environmental perception varies widely (Moore & Golledge, 1976). On the one hand, environmental perception refers to the initial gathering of information through the direct sensory experience of the environment (e.g., Rapoport, 1977). On the other hand, the concept of perception includes not only information gathering through senses but also "cognitive, imaginal, affective, and value aspects" people perceive in the environment (Ittelson, 1978, p. 197). In this sense, environmental perception can be considered as a function of the interaction between humans and the environment (Zube, Sell, & Taylor, 1982). When the term "perception" is used in this study, it refers to the broader definition of the latter. To avoid confusion, the former perception (information gathering) is called "visual perception" hereafter to differentiate from the latter.

The product of environment perception is called the *perceived environment.* The perceived environment is of particular interest in the EBS discipline (e.g., Fenton & Reser, 1988; Moore & Golledge, 1976). Magnusson (1981), for instance, made a clear distinction between " (1) the environment 'as it is' and (2) the environment 'as it is perceived,' construed, and represented in the mind of an individual who is appearing and acting in it on a certain occasion" (p. 3). In this distinction, a higher priority is often given to the perceived and recognised environment rather than actual physical features because of its critical influences on people's choice and behaviour (e.g., Moore & Golledge, 1976; Rapoport, 1982, 1994). In this sense, perception of the environment bears the vital importance to the relationships between people and the environment (Ittelson, 1978).

The idea of image and the perceived environment as defined here can be used interchangeably. In *Image of the City* (1960), Kevin Lynch describes an *image* as follows:

> Environmental images are the results of a two-way process between the observer and his environment. The environment suggests distinctions and relations and the observer—with great adaptability and in the light of his own purposes—selects, organizes, and endows with meaning what he sees. (p. 6)

The perceived environment is also based on sensory experience as well as knowledge and expectation (Rapoport, 1977). It can be argued that both ideas are a *personal construct* involving cognitive responses such as organisation, categorisation, and inference.

It needs to be noted that environmental perception involves not just the visual sense but also auditory, olfactory, and tactile senses (Rapoport, 1977; Ulrich, 1983). These nonvisual senses play an important role in the experience of the environment (e.g., Anderson, Mulligan, Goodman, & Regen, 1983; Chenoweth & Gobster, 1990). However, comparing visual and auditory stimuli, Gifford and Ng (1982) found that the visual sense dominates in participants' perception of the environment. Discussions in this thesis deal with perception of the visual aspect of the environment rather than the nonvisual aspects.

Figure 4 illustrates a conceptual diagram of environmental perception. The diagram starts with a physical environment that serves as stimuli for a perceiver. Environmental perception is based on the physical environment as well as human aspects. The human aspects include items such as cultural background, past experience, knowledge, attitudes, goals, and expectations (e.g., Nasar, 1994). Environmental behaviour, which is also under influence of human aspects, may follow environmental perception. In the present study, environmental behaviour covers "any changes people make in the environment: additions, modifications, destruction, or conservation" (Appleyard, 1979, p. 148). Thus the behaviour links back to the physical environment. This is a simplified view of the human-environment interaction. This diagram will be elaborated further in the course of this thesis.

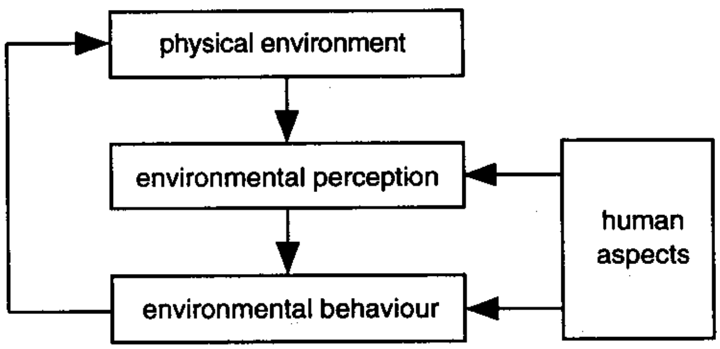


Figure 4. A simplified model of environmental perception.

Some words need to be added regarding environmental behaviour. The above definition of the environmental behaviour excludes many types of human behaviour such as spatial behaviour, which may happen as a result of the human-environment interaction. The spatial behaviour is not considered in this thesis because of its relative irrelevance to sustainable design. Furthermore, since the current study mainly focuses on environmental perception and environmental preference in particular, the environmental behaviour and prediction of the behaviour have a tangential importance in the thesis.

According to Rapoport (1977), environmental perception can be divided into the following three components: visual perception, recognition, and environmental evaluation or preference. The thesis employs the concept of *environmental preference* to explore issues relevant to sustainable design. "Preference" may sound insignificant or just a matter of opinion. However, preference is deeply related to a basic and underlying aspect of human mind, and environmental preference research has provided insights into the understanding of the human-environment interaction (e.g., S. Kaplan, 1988a). In the next section of the thesis, the study explores the concept of environmental preference in detail.

Environmental Preference

Overview of the concept

People like some environments but not others. The same environment may be preferred by one person but disliked by another. We consciously or unconsciously make evaluative judgements when we are in a certain environment (Kaplan & Kaplan, 1982a). Environmental preference, in essence, is one form of environmental evaluation (Nasar, 1994; Rapoport, 1977). The significance of the concept can be summarised as follows: (1) Environmental preference depends to some extent on the visual aspect of the environment (e.g., Nasar, 1994). (2) Preference reflects basic human needs and wants (S. Kaplan, 1987). (3) Preference for a given situation mediates behaviours and choices of an individual in the situation (S. Kaplan, 1987; Kaplan & Kaplan, 1982a).

A model of environmental preference as shown in Figure 5 illustrates these three points. As explained in the above, environmental perception is divided into three components in the diagram: visual perception, recognition, and environmental preference. The diagram indicates that environmental preference is based on the visual aspect of the physical environment as well as human aspects. The role of recognition in preference will be discussed later in this chapter. The diagram also indicates that preference for a certain environment may affect the

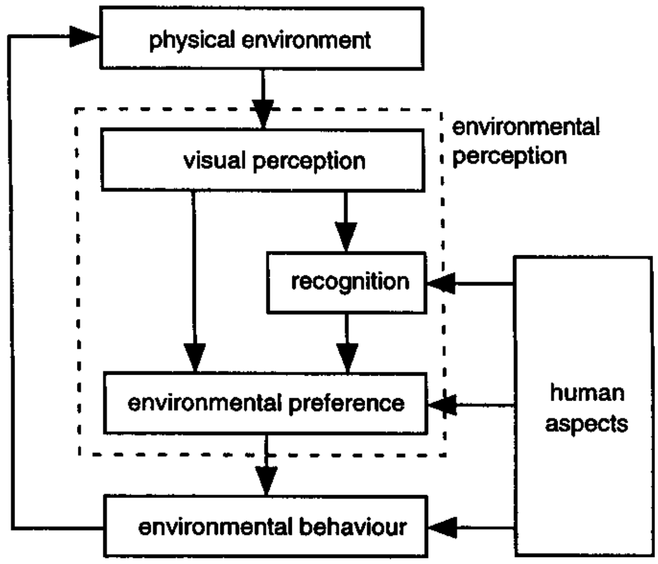


Figure 5. A model of environmental preference.

perceiver's environmental behaviour, which in turn may have some impacts on the physical environment.

The concept of environmental preference has been used in EBS for the purpose of environmental perception research and visual resource management since the 1960s (Zube et al., 1982). The aims of environmental preference studies include measurement, identification, and prediction of environmental patterns and attributes that people appreciate (Kaplan & Kaplan, 1982b). Some preference studies are directed to the solution of specific problems of visual resources, while other studies emphasise theoretical understanding of the human-environment interaction (Zube et al., 1982). Application of the concept of environmental preference has contributed findings in various types of visual resource management including housing (e.g., Nasar, 1989; 1994), urban streets (e.g., Maki, Inui, & Nakamura, 1994; Sheets & Manzer, 1991), parks (e.g., Hull & Harvey, 1989), forests (e.g., Herzog, 1984; Ribe, 1989; Thorne & Huang, 1991), and agricultural landscapes (e.g., Gómez-Limón & de Lucío, 1999; Nassauer, 1989). Accordingly, it has yielded important insights into design principles of the built environment (e.g., Hudspeth, 1986; Ulrich, 1983).

It is pertinent to place the concept of environment preference in a larger research framework. Several paradigms were identified in the research of environmental perception: expert, psychophysical, cognitive, and experiential (Zube et al., 1982). In the expert paradigm, the quality of the environment is assessed by skilled experts (Zube et al., 1982). The psychophysical paradigm employs the general public for evaluation of the environment in terms of scenic quality or preference. Its purpose is to identify effects of physical attributes of the environment on preferences (e.g., Hull & Harvey, 1989; Thorne & Huang, 1991). The cognitive paradigm is interested in lay people's preferences in conjunction with other perceived environmental quality and people's sociocultural status (e.g., Herzog, Herbert, Kaplan, & Crooks, 2000; Hodgson & Thayer, 1980). Finally, the experiential paradigm is phenomenological and in-depth exploration of the individual experience of the environment (e.g., Seamon, 1987). Since preference studies are normally interested in the perception of large numbers of lay people, they belong to the psychophysical or cognitive paradigm. The present study is interested in the relationship between preferences and *perceived* environmental characteristics, thus belongs to the cognitive paradigm.[1]

The implementation of environmental preferences is simply to measure the degree to which individuals like (or dislike) certain environments in a quantitative manner. In typical data collection processes, participants are asked to rate scenes on a scale ranging from most preferred to least preferred (e.g., Balling & Falk, 1982; Herzog, 1989). A 5-point or 7-point scale is often used for a response format. The scenes can be of existing places or of simulated environments. Typically, colour photographs or slides are used as stimuli. There have been some arguments regarding the use of two dimensional media as a surrogate of real environ-

1. Since the study belongs to the cognitive paradigm, the relationship between people's response and physical attributes of the environment will not be investigated in this thesis. Identifying such physical attributes might be an important task for a different type of study. Thus, it will be mentioned as a possible future research in the end of the thesis.

ments. This issues of validity and reliability of the use of photographs in preference research will be discussed in Chapter 5. After the data collection, preference rating data can be analysed at various levels. Information as to which scenes are highly liked or disliked is important in itself in many cases. Useful knowledge can also be obtained by comparing preference ratings between different groups of people (e.g., Brunson & Reiter, 1996; Devlin & Nasar, 1989; Herzog et al., 2000). In addition to the basic information, it is possible to identify underlying categories that represent the way people perceive the environment (R. Kaplan & S. Kaplan, 1989). The categorisation provides designers, planners, and policy makers with information concerning generalised environmental attributes that are likely to elicit certain common responses from people.

In the previous chapter, an argument was made for the significance of the sociocultural aspect of the environment. The thesis also has argued that social sustainable design, which incorporates the sociocultural aspect into its design principles, needs to be developed to promote sustainability. An important proposition of this study is that environmental preference can be an effective means to examine the sociocultural aspect of the environment. In other words, by measuring people's preference for a certain environment, it is possible to identify how well the environment "fits" with people and how well its sociocultural aspect is adequately incorporated in the environment. The significance of environmental preference applied to sustainable design will be discussed further later in this chapter.

Criticisms of environmental preference research

The term "preference" may be considered in common parlance as synonymous with taste, which implies arbitrariness or idiosyncrasy. One may claim that preferences have no underlying consistency, and thus have no significance in research. Another possible criticism concerning environmental preference is that aesthetics of the environment is an elitist point of view, hence does not represent the public interest.

Both criticisms are based on misunderstandings. Past studies on environmental preference have repeatedly demonstrated substantial communality in preference among individuals (e.g., Dearden, 1981; Lyons, 1983). Stronger communality in preference tend to exist within a group of people who share similar sociodemographic characteristics (e.g., Balling & Falk, 1982; Nasar, 1998). Variability in preference among individuals, which does exist, is accounted for to some extent in some studies (e.g., Hagerhall, 2000; Purcell & Lamb, 1984). Research has also revealed that a certain visual feature is likely to elicit a certain degree of preference (e.g., Nasar, 1994).

S. Kaplan and R. Kaplan (1989) offered a comprehensive explanation for both criticisms:

> Concern with the visual aspect is not a frill or luxury, nor is aesthetics the sole province of the affluent or of a group of experts. Rather, we take the position that the visual environment is continuously a source of information that humans require for effective functioning. Humans are likely to prefer settings that facilitate their functioning, environments where the information is manageable and interesting. From this perspective, a preferred environment is one that satisfies basic human needs. Thus aesthetics is an expression of a concern vital to all humans. (p. 65)

What is described above is called an *evolutionary theory* of environmental preference (S. Kaplan, 1987, 1988a). It is well known that people prefer natural scenes with vegetation and water (e.g., Herzog, 1989; R. Kaplan, 1983; R. Kaplan & S. Kaplan, 1989; Sheets & Manzer, 1991; Ulrich, 1981). According to the evolutionary theory, people prefer those scenes because vegetation and water are known to facilitate life of human beings (S. Kaplan, 1987). Appleton (1975), an English geographer, also developed a similar theory of *prospect and refuge*, in which habitat selection is linked with an evolutionary process. This does not necessarily mean that preference for a certain environment is solely determined by evolutionary/biological concerns. Cultural factors also influence preference judgments (Bourassa, 1990). However, the evolutionary theory suggests that environmental preference is not simply a matter of taste or just for the elite, but is grounded on our primordial necessity to function and survive in the environment (S. Kaplan, 1988a).

A conventional model of environmental preference

Preferences are primarily based on affective reactions (Zajonc & Markus, 1982). However, it is known that environmental preference is the outcome of a complex interaction of affective and cognitive responses toward environmental stimuli (S. Kaplan, 1987, 1988b; Lazarus, 1984; Ulrich, 1983; Zajonc, 1980). Affect in this thesis is fundamentally equivalent to emotion (Ulrich, 1983) and associated with feelings such as pleasantness, arousal, excitement, and relaxation (Russell, Ward, & Pratt, 1981). Cognition, on the other hand, involves acquisition, representation, and processing of visual, linguistic, semantic, and behavioural information (Moore & Golledge, 1976). It needs to be mentioned that cognition can include categorisation and inference, however it does not necessarily involve conscious and rational calculation (S. Kaplan, 1988b). A pair of keywords to better understand the concepts of affect and cognition is "innate" and "learned." It has been suggested that affect is mainly concerned with basic human needs, which are innate and relatively common across individuals and cultures, whereas cognitive reactions are influenced by learning, thus can vary widely with personal factors such as age, gender, culture, levels of education, values, attitudes, knowledge, and past experiences (Ulrich, 1983).

There has been considerable debate as to the relationship between affect and cognition in preference (Nasar, 1994). Zajonc (1980) explained with convincing evidence that initial responses to environmental stimuli can occur without participation of precise recognition. Neurophysiological research also asserts that emotional responses to the environment can happen independent of cognitive processes (Bourassa, 1990). This means that we can like something without knowing exactly what it is (Zajonc, 1980). What elicits affective responses at this stage is a gross and configurational aspect of the environment, which Zajonc (1980) called "preferenda." Formal and compositional qualities of the environment such as shape, proportion, balance, rhythms, complexity, colour, solid and void, openness, and texture are considered to be a part of the gross environmental characteristics (Berlyne, 1971; Punter, 1982; Wohlwill, 1976). This view of preference is mainly concerned with the structure of the environment rather than its content (Nasar, 1994). Since this mode of preference is based mainly on affect without extensive recognition (Zajonc, 1980), it is called "initial affective reaction" in the present study.

Following the initial affective reaction, detailed recognition of the environment may or may not happen. It relies on various factors, but it is believed that the initial affective reaction triggers the recognition process (Zajonc, 1980). Affect involves feelings such as arousal and interest. A certain environmental pattern may elicit interest, thus encourage a perceiver to explore the environment further (Ulrich, 1983). Preference can be formed after this recognition process in which visual information is processed and interpreted (S. Kaplan, 1988b). In this case, it is the contents of the environment that generate preference (Nasar, 1994; Wohlwill, 1976). Based on Russell (1988), this response is called "affective appraisal" in this thesis, because it not only involves the cognitive process (appraisal), but also is based on the initial affective reaction (Nasar, 1994).

Figure 6 shows a model of environmental preference which is separated into the initial affective reaction and affective appraisal. This model is based on, but modifies the diagram proposed by Ulrich (1983). The diagram illustrates a "conventional" model of environmental preference as discussed so far. A rectangle with rounded corners indicates a criterion for preference judgment. Namely, the model suggests that initial affective reactions are induced based on the perceiver's reaction to "formal qualities" of the environment. Affective appraisal, on the other hand, is based on perceiver's evaluation of the "contents" of the environment. Since the resultant observable environmental behaviour is not a major subject in this study, it has been removed from the diagram. Several feedback loops are also omitted from the diagram. Environmental preference is conceived as a sum of initial affective reaction and

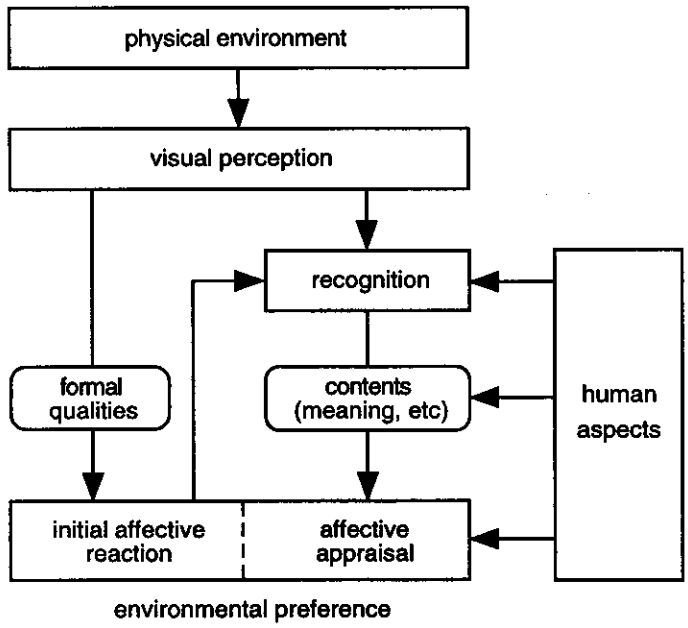


Figure 6. A conventional model of environmental preference based on Ulrich (1983).

affective appraisal. They are conceptual subdivisions. It is presumed to be difficult to isolate one component and examine it independently from others.

"Contents" of the environment, which influence affective appraisal, require further examination. First of all, meaning associated with the environment is an important content variable for environmental preference (Nasar, 1994). Rapoport (1982) has argued that it is the meaning of the environment that elicits our response to the environment. The built environment can be read as a set of signs that convey various meanings (Broadbent, 1980). Those signs, which are interpreted through cultural value systems, have several levels of values including material, use, exchange, and symbolic value (Biddulph, 1995). Meaning of an object is composed of these values (Bonta, 1980). It is important to notice that meaning and value of the environment is a product of interaction between the environment and people (Rapoport, 1982). Human aspects such as value orientation, social customs, cultural background, and past experiences are relevant to this cognitive process (Ulrich, 1983).

Secondly, naturalness of the environment also has a bearing upon preference (e.g., R. Kaplan, 1983; Sheets & Manzer, 1991). As described earlier, scenes of nature are preferred to scenes of human made objects. The previous discussion explained this preference from the evolutionary point of view, in which preference is innate and affective. However, it is also possible to argue that people prefer a scene with vegetation and water because of its cultural significance developed and learned over the course of time (Lyons, 1983). The two perspectives, i.e., the evolutionary theory and cultural constructivism, may not be exclusive to each other, because cultural values for vegetation and water may be a consequence of the recognition of their utility for continuation of human lives (Bourassa, 1990).

Thirdly, Kaplan and Kaplan (1982a) proposed several cognitive factors that influence environmental preference. Those factor are concerned with information available from a scene of the environment. The information may be immediately available or its presence is hinted within the scene. The information may allow a perceiver to make sense of the scene or to be involved in the scene. From these considerations, the Kaplans presented four predictors of environmental preference: coherence, complexity, legibility, and mystery. Empirical research identified that mystery is particularly an important variable in predicting people's preference for the environment (e.g., Gimblett, 1990; Herzog, 1984).

Finally, familiarity of an environmental stimulus is also considered a relevant content variable (e.g., Nasar, 1994). The built environment, once recognised, is tested against a knowledge structure or mental representation which one organises through experiences with various environments (Nasar, 1994; Purcell, 1986). Generally, it is believed that one find a setting that fits to one's knowledge structure to be pleasant (Herzog, 1984; Nasar, 1994). A slightly different theory claims that novelty or moderate discrepancy from one's knowledge structure, which elicits arousal, increases affective responses (Gaver & Mandler, 1987; Peron, Purcell, Staats, Falchero, & Lamb, 1998; Purcell, 1986). However, a recent empirical study reported that familiarity is not strongly correlated with environmental preference (Purcell, Peron, & Berto, 2001). As these research results indicate, the effect of familiarity on environmental preference appears equivocal.

The role of affect and cognition in environmental preference

Before examining preferences for sustainable design, it is worthwhile to discuss the role of affect and cognition in preference further. *Environmental aesthetics* is a field of study that has been exploring the relationship between cognition and affect. *Aesthetics* in general is defined by Carlson (2000) as follows:

> Aesthetics is the area of philosophy that concerns our appreciation of things as they affect our senses, and especially as they affect them in a pleasing way. As such it frequently focuses primarily on the fine arts, the products of which are traditionally designed to please our senses. However, much of our aesthetic appreciation is not confined to art, but directed toward the world at large. We appreciate not only art, but also nature... Moreover, our appreciation reaches beyond pristine nature to our more mundane surroundings.... (p. xvii)

As this statement suggests, aesthetics is not just for arts, but can cover a wide range of subjects including sustainable design, which belongs to "mundane surroundings."

The study of environmental preference is considered as a part of environmental aesthetics (e.g., Ataov, 1998; S. Kaplan, 1987; Nasar, 1994; Ulrich, 1983). *Aesthetic response* is defined as affective based appraisals or evaluations (Wohlwill, 1976; Nasar, 1994). In this sense, aesthetic response is essentially the same as conventional environmental preference discussed in the above (Ulrich, 1983). Traditionally, because of the influence of landscape painting, aesthetics of the environment is often deemed equal to the notion of picturesque or pictorial, which is strongly associated with affect (Gobster, 1999; Nassauer, 1997a). Researchers debate as to the significance of affect and cognition in environmental aesthetics. For instance, Parsons and Daniel (2002) argue against "ecological aesthetics" based more on cognition of functions of the environment to assert the primacy of "scenic aesthetics," which is highly affective.

However, the recent literature seems to suggest that environmental aesthetics expands beyond the realm of affect. For instance, Eaton (1997) defined aesthetic experience as being "marked by perception of and reflection upon intrinsic properties of objects and events that a community considers worthy of attention" (p. 88). Because of the serious public concern for the environment, the issues related to sustainability are likely to fit this criterion of aesthetics. She actually suggests that a nonperceivable and highly cognitive issue such as ecological health is also relevant to aesthetics of the environment.

In a similar direction, Carlson (1995) proposed to consider *appreciation* of the environment to extend the notion of aesthetics. According to Carlson, there are two components involved in the appreciation of the environment: one is cognitive, and the other is responsive (Carlson, 1995). He explained the significance of the cognitive component in appreciation using an example of music. "The point of a course in music appreciation, for example, is . . . to prepare the appreciator to respond appropriately to the music" (Carlson, 1995, p. 396). As this comment demonstrates, Carlson considers that a cognitive component such as knowledge and understanding serves as a "guide" to appreciate music. In the case of sustainable design, it is the understanding of functions regarding sustainability and their effectiveness that guide our aesthetic experience of sustainable design.

The idea of *aesthetics of engagement* asserted by Berleant (1988) is also pertinent to cognition of the environment. He argues that a classic model of aesthetics, in which an observer is removed from an object of appreciation and is contemplating it from a distance, may be applicable to landscape paintings, but not to the actual environment. Since we are a continuous and integral part of the environment, Berleant claims that the appreciation of the environment should be participatory rather than contemplative (Berleant, 1988). It is comprehension and knowledge of the environment that transform the environment from the one to be observed to the one to be engaged in an active manner (Gobster, 1994). The argument suggests that recognition of the environment is likely to change people's experience of the environment. The importance of knowledge in aesthetic appreciation of the environment is also advocated in a classic work, *A Sand County Almanac*, by Leopold (1981). The arguments cited here suggest that environmental aesthetics is expanding its sphere by shifting its emphasis from affect toward cognition.

In the previous chapter, the thesis discussed that less attention to the visual aspect of sustainable design is a possible obstacle to its proliferation. Environmental aesthetics relates the issue of affect and cognition to the visual aspect of the environment. Discussing appreciation of nature, Saito (1998), for instance, argued as follows:

> What is important . . . in nature appreciation is that (1) these appreciations are anchored in the scientific understanding of the object's origin, history, and function, but (2) such scientific understanding is incorporated *insofar as* it illuminates the sensuous surface of the immediate object. (p. 105, original emphasis)

In this statement, Saito emphasised the significance of the sensuous and affective quality of environmental experience that is adjusted and reinforced by conceptual and cognitive understanding of the environment.

The relationship between affect and cognition has been discussed in several fields other than environmental aesthetics. Recent studies in risk perception have reported associations between risk-benefit judgments with respect to an object and affective responses toward that object (e.g., Peters & Slovic, 1996). Rochford and Blocker (1991), for instance, surveyed people's perception of a flood and their feelings of threat. These researchers found that an assessment that a flood is controllable (cognitive evaluation) is correlated with fear of future flooding (affect). Similarly, studies of environmental stress documented the link between affect and cognition (e.g., Evans & Cohen, 1987). For example, one study discovered that a person's recognition that noise can be controlled (a perceived control over noise) has a positive effect on person's emotional status in comparison to a situation in which respondents have no control over the noise (Glass, Singer, & Pennebaker, 1977).

Another characteristic of affect and cognition is worthy of attention here. In the previous section, the thesis discussed that affective reactions tend to be innate, whereas cognitive responses are likely to involve learning and knowledge. The implication of this argument is that some learned cognition-based preferences may be altered by cognitive means of persuasion, whereas affect-dominated preferences may not be amenable to persuasion (K. Edwards, 1990). For instance, preferences for a clear blue ocean or the mountains in the Alps may not be changed by persuasive information. On the contrary, preferences for a certain car, which may be formed based on knowledge about its performance or price, may be altered by supplying further information. It should be added that some learned preferences acquired in childhood, for example, preference for chili pepper, are primarily formed on an affective basis (Zajonc & Markus, 1982). This type of preference is also not susceptible to change by persuasive information. The issue of persuasion and alteration of preferences will be discussed further in this thesis.

Preferences for Sustainable Design

An expanded model of environmental preference

All the above arguments point to the important role of cognition in our experience of the environment. Studies have also reported that people recognise and recall the built environment in terms of its functional significance rather than its formal attributes (Appleyard, 1969; Downs & Stea, 1973; Moore, 1979). This implies that preferences for the built environment may be influenced by recognition of its service and functions. In the case of sustainable design, it is possible to hypothesise that an environment evaluated as being sustainable is likely to be preferred over another environment evaluated as being less sustainable. This argument may be reinforced by the fact that the number of people who support a proenvironmental world view is high and increasing (e.g., Arcury & Christianson, 1990; Dunlap, Gallup, & Gallup, 1993).

Based on the discussion so far, the present study considers that the conventional model of preference as shown in Figure 6 falls short of adequately addressing preferences for sustainable design. Cognitive components such as function, efficiency, and sustainability of the built environment cannot be dealt with in the conventional model of preference. The study, therefore, proposes a new model of environmental preference that includes cognitive components in order to address preferences for sustainable design. Although researchers concur that cognitive elements have some effects on affective reactions (e.g., S. Kaplan, 1987; 1988b; Zajonc & Markus, 1982), the extent to which cognitive evaluation influences preferences has not been investigated in the context of sustainable design.

Figure 7 illustrates the expanded model of environmental preference for sustainable design. In addition to affective appraisal, which involves both affect and cognition, the model includes "post-cognitive affective appraisal" that relies more on cognition. In the model, a criterion that leads to this response is considered to be "evaluation of sustainability." This relationship between the two elements represents the hypothesis that people's evaluation of sustainability influences their preferences for sustainable design. It is also hypothesised in this model that both evaluation of sustainability and preference are influenced by personal factors. In the thesis, preference for sustainable design is considered to be composed of the three components: initial affective reaction, affective appraisal, and post-cognitive affective appraisal. As mentioned before, they are conceptual subdivisions within a continuum of preference. Thus, they may not be separated from each other.

Previously, this thesis discussed that preference is one form of evaluation. In order to distinguish evaluation in this sense and evaluation of sustainability, the thesis employs the terms "cognitive evaluation" or "evaluation of sustainability" to denote the latter. It should be

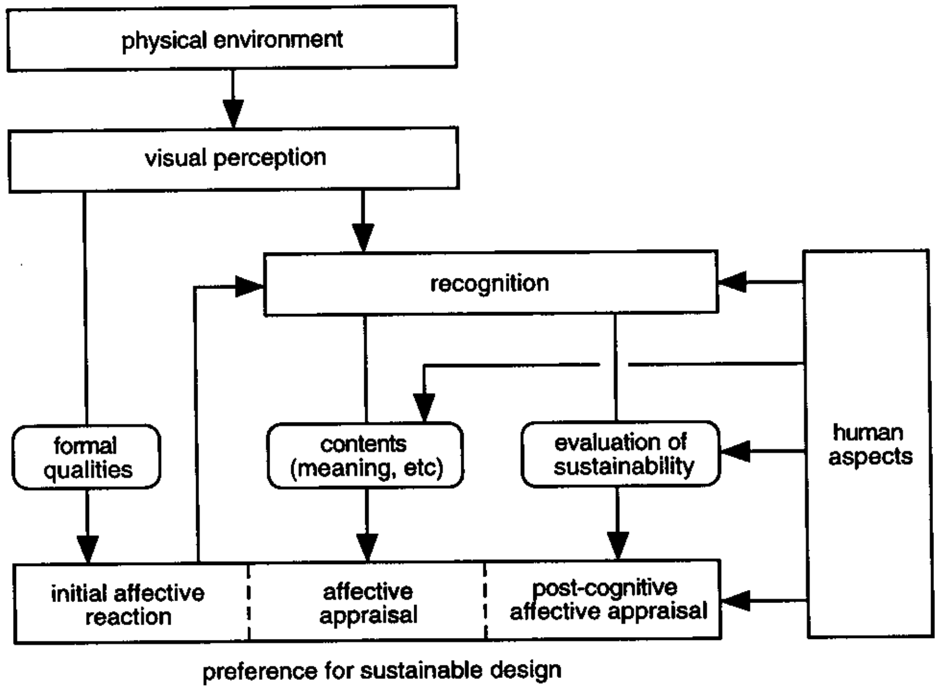


Figure 7. An expanded model of environmental preference for sustainable design.

stressed that "evaluation of sustainability" is not an actual physical degree of sustainability but a perceived degree of sustainability assessed by an individual.

Although the study is interested in the relationship between affect and cognition, what is measured in the study is not affect itself but preference. It appears that measuring affect isolated from cognition is quite difficult. In the studies of affect and cognition by Zajonc (1980) and K. Edwards (1990), Chinese characters, which are meaningless to respondents, were used to isolate the influence of cognition. However, in the case of this study, stimuli are examples of sustainable design that are likely to be loaded with significance and meaning. Thus, the study addresses the relationships between preferences and cognitive evaluation relevant to sustainable design.

The thesis has examined the interaction between people and the environment from a perspective of environmental preference. The roles of affect and cognition including evaluation of sustainability have also been discussed in the expended model of environmental preference. However, no human aspects have been discussed so far. In the following sections, human variables presumed to be related to environmental preference, i.e., environmental knowledge, attitudes, and culture, are reviewed.

Environmental knowledge

Sustainable designs are planned, designed, and constructed to improve sustainability in the environment by resolving or alleviating particular environmental problems. To appreciate sustainable design, one needs to know as to what environmental problems are being engaged and in what way sustainable design deals with the problems. One is supposed to have knowledge on these issues to appreciate sustainable design. As appreciation of the sky full of stars is enriched by the knowledge of astronomy (Carlson, 1995), appreciation of sustainable design will be sharpened by the knowledge with respect to flows of energy and material in the environment. What knowledge does in this context is to give a perceiver a focus of appreciation by bringing certain features into the foreground (Carlson, 1979). This "foregrounding" is quite important, because, in the case of sustainable design, people often do not know *what* to appreciate (Nassauer, 1992) .

A noteworthy problem in the perception of sustainable design is lack of "visibility" of sustainability (Hough, 1995; Mozingo, 1997). As discussed before, identifying sustainable design is a difficult task, because appearance of sustainable design often does not exhibit any signs of sustainability (Nassauer, 1992). In addition, ecological processes underlying sustainable design are simply unperceivable to humans (Mozingo, 1997). Due to the above situation, we do not know exactly "what ecological health *looks like*" (Eaton, 1997, p. 93, original emphasis). However, the problem of difficulty of recognising sustainable design is also related to the lack of proper knowledge in people. The lack of knowledge, in this sense, may be one factor that impedes propagation of sustainable design (Mozingo, 1997). It has been suggested that our education has failed to equip us with "ecological literacy" (Orr, 1992). Providing people with knowledge or information can be an effective means to help them recognise the intention of sustainable design and attract more public attention (Gobster, 1994). It can be argued that more knowledge about sustainable design among people as well as easily recognisable sustainable design are required to rectify the current situation.

Empirical studies confirm the influence of knowledge on environmental preference. Buhyoff, Leuschner, and Wellman (1979), for instance, examined the effect of knowledge on preference by using photographs of a forest damaged by pine beetles. In their experiment, participants in a treatment group were informed that they would evaluate forest scenes with the beetle damage, while those in a control group were simply asked to participate in a landscape preference test. The researchers reported that informed respondents showed decreasing preferences for damaged forest scenes. However, because of the orange-brown colour of damage rendered by the pine beetles, preference ratings by uninformed respondents actually increased with the increased amount of damage in forest scenes.

In a similar investigation, Hodgson and Thayer (1980) examined how knowledge of the environment changes aesthetic evaluation of the environment. Two sets of photographs with different labelling captions were used as stimuli. The first set had labels suggesting natural setting such as pond, stream bank, and forest growth, while the second set (the same photographs) had labels implying human influence such as reservoir, road cut, and tree farm. Respondents in a control group were asked to rank the photographs with natural labels among other photographs in terms of aesthetics. Respondents in a treatment group were asked to do the same with the photographs implying human influence. The results of the experiment indicated that knowledge of human involvement in an environment lead to a decrease in the judgement of beauty.

These empirical studies demonstrate that knowledge and information about a certain environment can change people's preference for the environment. It is possible to argue that, in this process, what is influenced directly by information is cognitive evaluation of the environment (the tree is damaged by beetles, this is a human-made reservoir). A change in preference seems to be a result of the change in cognitive evaluation. This hypothesis will be examined in this thesis.

Figure 8 illustrates the relationship between environmental knowledge, evaluation of sustainability, and environmental preference in the expanded model shown in Figure 7. As the diagram indicates, environmental knowledge affects evaluation of sustainability, which in turn influences post-cognitive affective appraisal. The process of recognition is also considered to be influenced by environmental knowledge, because recognition involves mental activities such as filtering, categorisation, and inference, which are based on individual knowledge and experience (Moore & Golledge, 1976).

Despite the significance of environmental knowledge, previous research has found that pub-

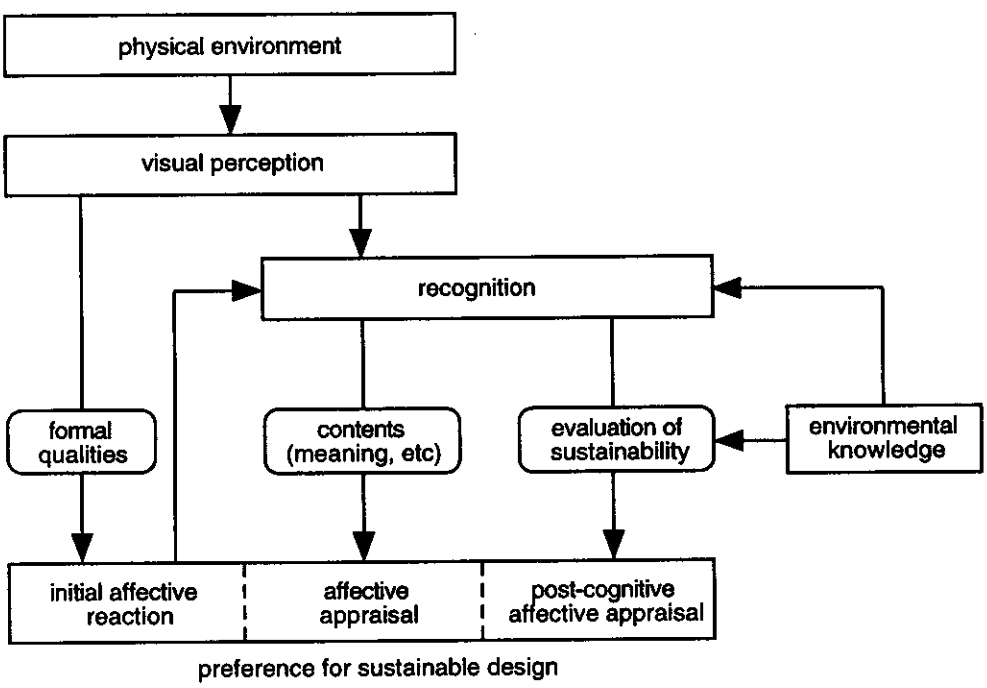


Figure 8. The expanded model of environmental preference including the hypothetical effects of environmental knowledge.

lic knowledge levels concerning environmental issues are relatively low (e.g., Arcury, 1990; Arcury & Johnson, 1987; Dunlap & Van Liere, 1978). For example, a study by Hausbeck, Milbrath, and Enright (1992) demonstrated that participants, 3,200 eleventh-grade school students in the state of New York, scored low in environmental knowledge questions in spite of their strong concern about the environment. Arcury and Johnson (1987) found no improvement of public environmental knowledge level between the US national survey in 1980 and a statewide survey in Kentucky in 1985. Having reviewed studies on environmental education, Gigliotti (1990) commented that environmental education has produced emotionally concerned citizens who are "armed with ecological myths" but lack basic environmental knowledge (p. 9).

Since the idea of sustainability is rather new, people are unlikely to have extensive knowledge about sustainable design. Due to the situation, people are often unaware of existence of sustainable design. Thus, environmental knowledge has an important role of informing people about environmental problems and strategies to resolve or mitigate the problems. Proper knowledge about sustainable design may also alter people's preferences for sustainable design through correct evaluation. However, because little research has been conducted in this area, the possibility of environmental knowledge as a catalyst of preferences for sustainable design has rarely been investigated.

Environmental attitudes

Rokeach (1968) defined an *attitude* as "a relatively enduring organisation of beliefs around an object or situation predisposing one to respond in some preferential manner" (p. 112). In the case of *environmental attitudes* or *attitudes toward the environment*, two types have been reported: "attitudes toward ecology and the environment as a whole, and attitudes toward taking environmental action" (Hines et al., 1986/87, p. 4). Environmental attitudes discussed in the current study refer to the former.

Attitudes toward the environment have been studied extensively. Studies of environmental attitudes include construction and examination of attitude scales such as "New Environmental Paradigm" (e.g., Dunlap & Van Liere, 1978; Geller & Lasley, 1985; Noe & Snow, 1990), investigation of the relationship between attitudes and environmentally responsible behaviours (e.g., Kaiser, Wölfing, & Fuhrer, 1999; Oskamp et al., 1991; Scott & Willits, 1994), and the relationship between attitudes and knowledge or education (e.g., Arcury, 1990; Gigliotti, 1990; Pooley & O'Connor, 2000).

These studies in general indicate that people's concern for the environment is reasonably high and increasing (e.g., Scott & Willits, 1994). Using the New Environmental Paradigm (NEP) scale consisting of twelve statements describing the relationships between human and nature, Dunlap and Van Liere (1978) found that almost three quarters of their respondents "agreed" or "strongly agreed" with proenvironmental statements. In a subsequent study, Dunlap et al. (1993) detected that the average acceptance rate of eight of the original twelve NEP items increased from 71 percent in 1976 to 78 percent in 1990. Other studies also report that more people have been accepting a proenvironmental world view (e.g., Arcury & Christianson, 1990). However, studies have also demonstrated that the links between support for the NEP items (positive environmental attitudes) and environmentally responsible behaviours are not strong (e.g., Hines et al., 1986/87; Scott & Willits, 1994).

The relationship between attitudes and preference needs to be clarified. Eagly and Chaiken (1993) explained that "attitude is an evaluative state that intervenes between certain classes of stimuli and certain classes of responses" (p. 3). They also argued that attitude is a latent process that is not directly observable. Figure 9 shows the relationship between environmental stimuli, attitudes, and responses. It is possible to argue that "evaluative responses" in this diagram is equivalent to environmental preference. However, preferences are not exactly the same as "revealed" attitudes because of the difference in stimuli between attitudes and preference. In the case of environmental attitudes, the attitude object is the environment as a

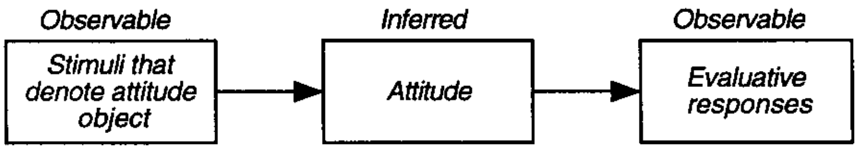


Figure 9. Attitude as an inferred state between stimuli and responses. *Note.* From *The psychology of attitudes* (p. 3), by A. H. Eagly & S. Chaiken, 1993, San Diego, CA: Harcourt Brace Jovanovich.

whole (Hines et al., 1986/87). On the other hand, a stimulus for environmental preference is a specific example of the environment. However, a general and latent process of environmental attitudes is expressed, in one sense, as a specific and observable preference for sustainable design. Thus, it is possible to postulate that those who have proenvironmental attitudes will respond favourably to sustainable design.

Proenvironmental attitudes will make little difference in preferences for sustainable design if an observer does not notice the sustainability of the design. As discussed earlier, one may need environmental knowledge to identify sustainable design. In this sense, the relationship between attitudes and preference is likely to be mediated by environmental knowledge. Similarly, it appears that environmental attitudes mediate the relation between cognitive evaluation and preference. Even when one finds a particular environment sustainable, whether the environment is preferred or not hinges to some extent upon his or her environmental attitudes. As Rokeach (1968) described, "the two dimensions of *like–dislike* and *goodness–badness* need not necessarily go together" (p. 121, original emphasis). These arguments suggest that preference, evaluation of sustainability, environmental knowledge, and attitudes are related in an intricate manner.

Figure 10 is a diagram showing the expanded model of preference with environmental knowledge and attitudes. It is postulated that environmental attitudes influence people's post-cognitive affective appraisal. It is also predicted that people's attitudes toward the environment

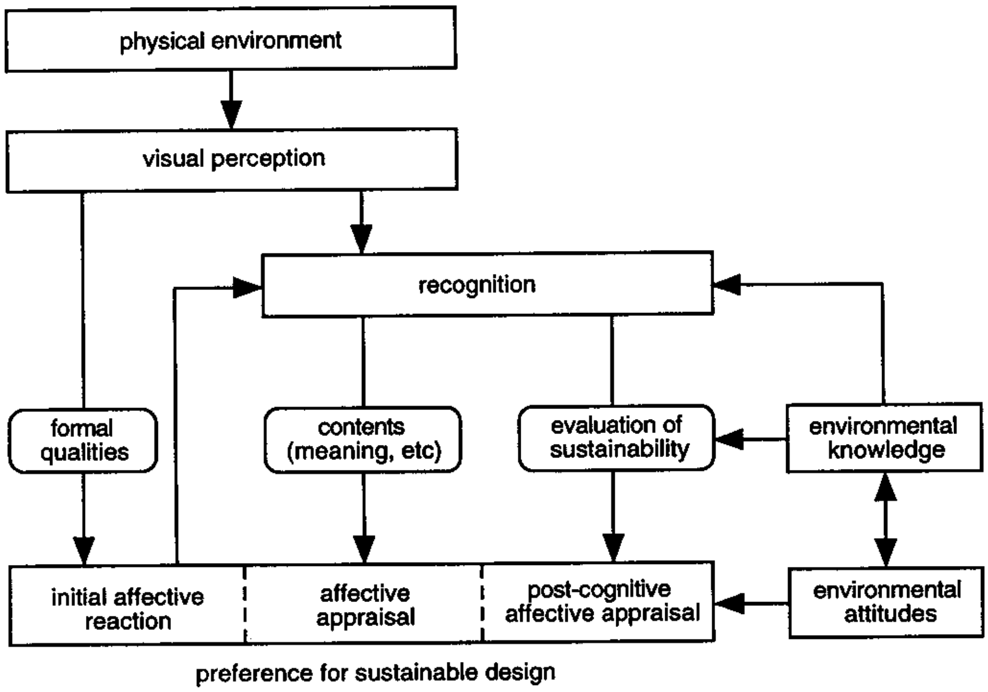


Figure 10. The expanded model of environmental preference including the hypothetical effects of environmental knowledge and environmental attitudes.

and environmental knowledge influence each other. Past studies have suggested that factual knowledge is a necessary precondition for any attitude formation (e.g., Campbell, Waliczek, & Zajicek, 1999; Kaiser et al., 1999). For instance, one's attitudes toward nuclear power generation are dependent on the person's knowledge of its possible benefits and danger. On the other hand, stronger environmental attitudes may lead to further learning and knowledge about the environment (Arcury, 1990). Those who are concerned with nuclear power generation may want to learn more about it. Previous research does not seem to have addressed the relationships between preference, cognitive evaluation, environmental knowledge, and attitudes in an empirical manner.

Cultural influences

It is well known that culture influences the environment and is influenced by the environment (Altman, Rapoport, & Wohlwill, 1980). Rapoport (1980) explains the definition of *culture* in relation to the built environment:

> One defines it as a way of life typical of a group, the second as a system of symbols, meaning, and cognitive schemata transmitted through symbolic codes, the third as a set of adaptive strategies for survival related to ecology and resources. . . . For our purposes, then, culture may be said to be about a group of people who have a set of values and beliefs which embody ideals, and are transmitted to members of the group through enculturation. These lead to a world view—the characteristic way of looking at the world and, in the case of design, of *shaping* the world. (p. 9, original emphasis)

As this definition points out, culture plays a crucial role in the interaction between humans and the environment. In fact, it is suggested that human impacts on the environment can be understood as a complex interplay between culture and nature (Diesendorf & Hamilton, 1997). In this sense, culture is also likely to affect the way people resolve environmental problems and approach sustainability.

The above definition by Rapoport (1980) suggests that culture has a bearing on the way people cope with environmental problems. Empirical research backs his argument. In a study on perceptions of environmental problems in Japan and the United States, McGlen, Milbrath, and Yoshii (1979) found that what is considered as an environmental problem is different between the two countries. Comparing the same two countries, Jussaume and Higgins (1998) also found that Japanese respondents are more likely to give a high priority to environmental protection than the American counterpart. Another study by Bechtel, Verdugo, and Pinheiro (1999) identified differences in environmental attitudes between American, Brazilian, and Mexican college students. Even within Asia, Hashimoto (2000) discovered minor differences in perceptions and attitudes toward environmental issues between Chinese, Taiwanese, and Japanese people.

However, different cultures do not always lead to differences in responses to environmental issues. Ulrich (1983) commented that "the similarities across cultures in terms of perception and cognition are much more impressive than the differences" (p. 109). Many cross-cultural studies conducted to date have demonstrated a considerable similarity in environmental preference across different cultures (e.g., Herzog et al., 2000; Hull & Revell, 1989; Kaplan & Herbert, 1988; Newell; 1997; Tips & Savasdisara, 1986). For instance, Buhyoff, Wellman, Kock, Gauthier, and Hultman (1983) found similarity in preference for forest scenes between respondents from the United States, Netherlands, Denmark, and Sweden. Similarly, in a study of scenic beauty evaluation of landscapes in Bali, Indonesia, Hull and Revell (1989) reported substantial agreement between local Balinese and mostly Western tourists. A few studies reported significant intercultural differences. Comparing preferences for urban street scenes in Japan and the United States, Nasar (1984) found that Japanese and American respondents prefer foreign scenes over scenes in their own country. A study by Zube and Pitt (1981) also showed that respondents from Virgin Islands, the United States, and Yugoslavia are different in their preferences for scenes of coastal development in Virgin Islands.

It can be argued that affect and cognition are involved in similarities and differences of preferences between cultures. A possible reason for cultural similarities of preference in the above studies is that they used predominantly natural scenes as stimuli (Buhyoff et al., 1983; Herzog et al., 2000; Hull & Revell, 1989; Kaplan & Herbert, 1988; Newell, 1997; Tips & Savasdisara, 1986). As S. Kaplan and R. Kaplan (1982) and Appleton (1975) have argued, people prefer a setting which facilitates their functioning and safety. This type of primordial concern, which is innate and affective, may play a greater role in preference for natural scenes than for urban scenes. In addition, Nassauer (1983) suggested that in "scenic" natural landscapes, formal composition of a scene is likely to have a stronger influence on people's preference. As mentioned before, formal aesthetics tends to induce affective responses that are likely to be similar between different cultures. Thus it can be considered that preferences for natural scenes are based more on affect.

It appears that cultural differences in preference are found when scenes with built structures are involved (e.g., Nasar, 1984). It can be argued that preferences for scenes with human-made structures are conditioned by cognition, since they tend to depend on experience, learning, and knowledge (Zube & Pitt, 1981). Thus, preferences for built structures are more likely to differ between different cultures. In the study of streetscape in Japan and the US by Nasar (1984), "novelty" perceived in the foreign streetscape may have induced different cognitive responses between the Japanese and American respondents. In the study of coastal development in Virgin Islands, Zube and Pitt (1981) found that Virgin Islanders, unlike the other groups of respondents, did not consider buildings (resort hotels and apartments) on a beach necessarily reducing scenic beauty. These buildings look beautiful to Virgin Islanders, perhaps because the building embody their cultural expectation to some extent. In support of this argument, Hagerhall (2001) found that a scene requiring extensive cognitive evaluation tends to have higher variance (less consensus) in preference judgement.

In summary, the above arguments suggest that if cultural differences in preference for the environment exists, they are likely to be generated by different cognitive responses to the environment. This may be also the case with sustainable design, as preferences for sustainable design are likely to involve comprehension of its utility for appreciation. In other words, it can be hypothesised that cultural differences in preference for sustainable design may happen as a result of different evaluation of sustainability. In this sense, a cross-cultural study on preference for sustainable design provides an interesting opportunity to study the relationship between preference and cognition.

Figure 11 illustrates the expanded model of environmental preference showing the roles of environmental knowledge, environmental attitudes, and culture. In this study, it is postulated that culture influences preference, evaluation of sustainability, environmental knowledge, attitudes, contents people perceive in the environment, and the recognition process. Figure 11 also indicates the scope of the study. Bold rectangles and arrows are constructs and relationships examined empirically in the study.

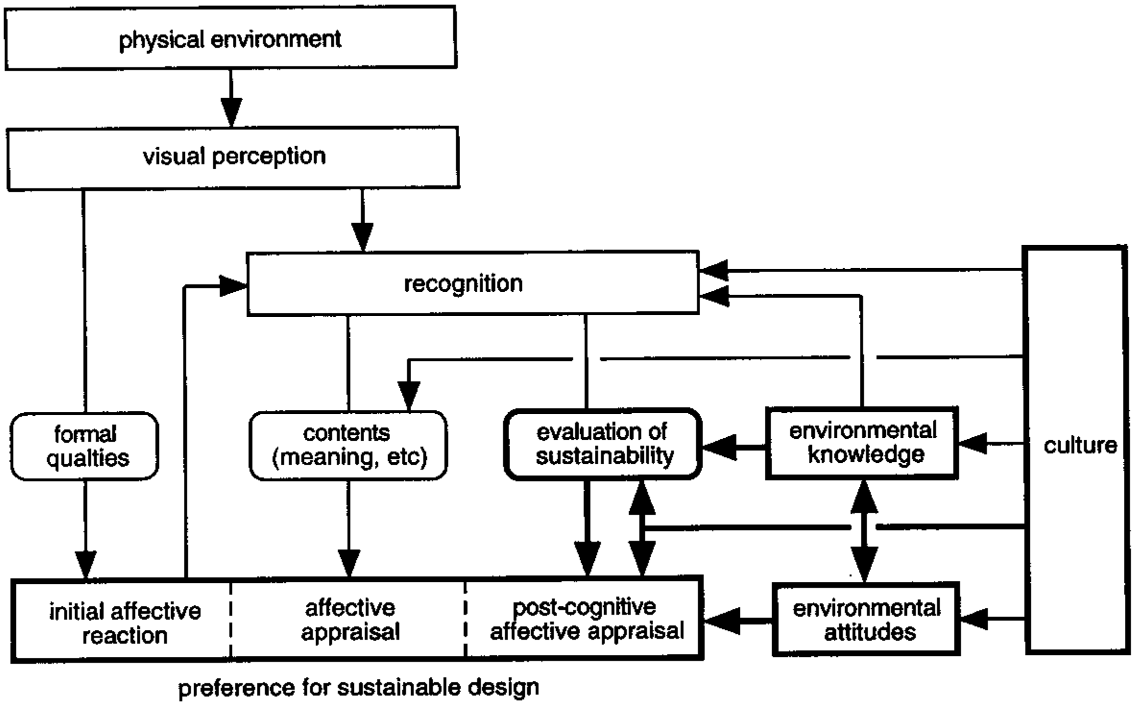


Figure 11. The scope of the study and expanded model of environmental preference including the hypothetical effects of environmental knowledge, environmental attitudes, and culture. *Note*. Rectangles and lines drawn in bold will be studied in the empirical part of this thesis.

Significance of Preference in Sustainable Design

This thesis is based on an assumption that increasing people's preferences concerning the environment will contribute toward promoting sustainability. It is because environments people prefer are more likely to attract support from people (Mozingo, 1997). If a certain type of environmentally friendly design meets expectation of people, then it has a better chance of being chosen often, used widely in a society, and maintained in a long period, which in turn leads to enhancing sustainability in the built environment.

Precedents support this assumption. In Denmark, a nationwide energy policy to promote wind energy production, which includes local ownership of wind turbines and distribution of benefits to households, has led to a high degree of community acceptance for wind energy production (Taylor & Rand, 1991). Those who accept wind energy are more positive about local wind turbines and find them less intrusive to landscape (Gipe, 1995). An Italian hill town, which still maintains 600-year-old structures, is another example of sustainable design. The reason for this longevity is that it has aesthetics value people consider worth preserving (Wines, 2000). Furthermore, in the southwestern part of the United States, because of a change in culture and perception, arid-adaptive landscape design has gained popularity, thus replacing conventional lawn that requires considerable amount of water for maintenance (McPherson & Haip, 1989). It is obvious that this type of a large-scale perceptual change and following public adoption of sustainable design are highly effective in promotion of sustainability. The importance of the public support is further validated by the recent active participation of citizens in environmental design and planning decision-making processes (e.g., S. Kaplan & R. Kaplan, 1989).

It has to be noted here that *measuring* preference for a certain environment and *altering* preference are totally different activities. The former is the original purpose of environmental preference studies, but the latter involves *persuasion* with various means. Besides the identification of preferences for several different types of sustainable design, this thesis is also interested in understanding some of the factors which can change people's preferences for sustainable design. In the following, the thesis summarises the significance of measurement of environmental preference and then points out the importance of "preferred sustainable design."

An important contribution of environmental preference to the built environment in general is the measurement of the visual quality. Traditionally, the visual aspect of the environment has been excluded from considerations of design and planning processes, because aesthetics of the environment has been thought too elusive to measure and too unreliable to study (e.g., Hudspeth, 1986; Maguire et al., 1997; Sancar, 1985). However, as discussed previously, the environmental preference procedure can successfully measure the visual aspect of the environment in a quantitative manner.

Preference ratings by the public can also serve as a check process of the built environment designed by experts. It is well known that professional designers not only have different preferences than the public, but also tend to have a limited capacity to predict what the public would prefer (e.g., Devlin & Nasar, 1989; Hershberger, 1988; S. Kaplan & R. Kaplan, 1989). Data gathered in the process of environmental preference can provide designers, planners, and policy makers with substantial information that can be used as a basis for their design and planning decisions (S. Kaplan & R. Kaplan, 1989).

Activity of measuring people's preferences itself can be an effective means to facilitate citizen participation in an environmental decision-making process (e.g., Hudspeth, 1986). Data collection of environmental preference is quite simple and straightforward compared to other forms of participation such as public hearing (S. Kaplan & R. Kaplan, 1989). Compared to a burden and frustration involved in the hearing process (understanding information provided by experts and articulating opinions verbally), it has been reported that people are capable of evaluating visual images and expressing their preference without any difficulty (S. Kaplan & R. Kaplan, 1989). In addition, because of its simple and straightforward method, a preference rating procedure can collect responses from a large number of people, which leads to a better chance of representing the public interest. It should be also noticed that participants can see how their involvement is reflected to a decision-making process, thus find the preference rating process intuitively meaningful (Hudspeth, 1986).

The significance of "preferred sustainable design" needs to be discussed. As S. Kaplan (1987) described, a preferred environment satisfies basic human needs and wants to some degree. It can be argued that preference for a certain environment represents the extent to which people appreciate and accept the environment. As stated earlier, if some type of sustainable design is easily acceptable by the public and coincides with cultural expectations, it is likely to be chosen and replicated by local governments, companies, communities, and designers (Mozingo, 1997). This implies that success of sustainable design partly hinges on public acceptance. Although, "acceptability" is a multidimensional construct, past studies have used the aesthetic quality as one dimension of this construct (e.g., Brunson, 1993).

Preference is an intuitive guide to individual behaviours and decision-making processes (S. Kaplan, 1987; Zajonc & Markus, 1982). Thus, preference may induce individual behaviours beneficial to the environment in addition to simple acceptance. Environments people prefer may be sustained by appropriate human care and stewardship (Nassauer, 1997a). In this sense, environmental preference has been deemed as one of the important driving forces that shape our environment (Ross et al., 1994). For instance, those who are planning to relocate may opt to rent an apartment in an urban setting or build a detached house in a suburban setting. Obviously, this type of decision involves a very broad range of factors other than preference, but individual preference among possible options plays a crucial role in the process (Appleyard, 1979). Thus, by considering people's preferences in the construction of sustainable design, it may be possible to shape the environment toward sustainability through people's choice and behaviour.

Furthermore, environmental preference can be used to evaluate various measures to promote sustainable design. Although it may still not be common practice, there have been some attempts to gather public support for sustainable design. One typical example of such enterprises is environmental education including programs to experience ecological environments, public seminars, and provision of various types of information (Gobster, 1994, 1999). Other attempts include a particular way of design, planning policies, and management practices (e.g., Gobster, 1999; Thayer, 1994). By comparing preferences for a certain environment with and without those interventions, it is possible to understand how successful they are in promoting sustainable design.

Previous Studies of Preferences for Sustainable Design

A few studies to date have addressed issues related to environmental preference for sustainable design. One group of studies is interested in "ecological aesthetics." This group focuses predominantly on theoretical understanding of the issue related to perception of sustainable design. The other group, which contains only a few examples, explores preference for sustainable design empirically. In this section, the thesis reviews these past studies and points out some topics that have not been investigated before.

Theoretical approaches

It is observed that aesthetics and ecology often conflict with each other (e.g., Gobster, 1999; Sancar, 1985). For instance, those who lack knowledge in ecology often describe ecological sustainable design as unkempt or messy (e.g., Gobster, 1994; Mozingo, 1997; Nassauer, 1992). Other studies have reported that environments managed for ecology tend to be less aesthetically pleasing than those managed for scenic quality or recreation (e.g., Brunson & Reiter, 1996; Parsons, 1995). Mozingo (1997) explains the indifference of those who are involved in ecology toward social issues including aesthetics:

> Like modernist in design, the ecological design ethics derives its abstraction, anti-humanism, and ahistoricism from culturally naive science, in this case biological science rather than social science.... It does not overtly integrate the need for intimacy, sensuality, familiarity, orientation, delight, and occasional splendor in the experience of the everyday world. (p. 57)

Ecological aesthetics is an attempt to resolve this conflict by integrating aesthetics and sustainability values (e.g., Gobster, 1994; Mozingo, 1997). In our current value structure, aesthetics is considered as one of the important values people attach to the environment (Gobster, 1999; Kapper & Chenoweth, 2000). Since our value structure is quite enduring (Rokeach, 1968), it is unfruitful and naive to disregard this important value, especially when people's involvement is expected. As Lyle (1994) pointed out, we "cannot afford not to use all the knowledge and skill at our disposal, and we certainly cannot ignore our feelings or our yearning for visual meaning" (p. x). By integrating aesthetics into sustainable design, it is possible to engage people's interests and influence their perceptions toward sustainable design. In this sense, aesthetics provides a powerful means to establish a link between people and sustainable design.

One step to unite aesthetics and ecology is to reveal ecological functions and assert its existence (Nassauer, 1995b, 1997a; Thayer, 1989). As mentioned before, one problem of ecological sustainable design is that it is often invisible for ordinary people (e.g., Nassauer, 1992). To rectify this situation, Thayer (1989) advocates the importance of "conspicuous design" in which intentions and functions of sustainable design are visible from its appearance. Thayer (1994) also used the term *visual ecology* to explain the significance of the visibility:

> Without being able to see the workings of our own landscapes, we may be unable to make necessary adjustments to changing environmental conditions. The feedback of experience between habitat and organism which guides environmental behavior is a cornerstone of ecology. In transparent landscapes, a *visual ecology*, where we are able to assess the conditions affecting us and make cogent environmental decisions, is both possible and necessary. (p. 311, original emphasis)

Just revealing ecological functions, however, may not be enough to integrate values of sustainability and aesthetics, because what is expressed may not be congruous with the current values of a society. Although authors in this area agree on revealing ecological functions as a right step toward ecological aesthetics, they do not concur as to what way the functions are disclosed. In this regard, Thayer (1989) considers that "art" has an important role in the process. He describes that "artful interpretation of the human/land relationship offers a range of possible aesthetic futures by which sustainable landscapes can be identified, emphasized, measured, and made visible" (Thayer, 1989, p. 108). Howett (1987) also asserts that through artistic representation, art of the environment ought to "awaken the public to a more holistic appreciation of the natural world" (p. 6).

This artistic approach, however, is questioned by some other researchers due to its ineffectiveness in communicating with people. Eaton (1990) argued that we cannot communicate by using an entirely new or private language, and proposed to extend a culturally recognised vocabulary. As argued earlier, reiteration of form in a society leads to construction of social meaning of the form (Rapoport, 1982). In this sense, an artistic and innovative design approach is unlikely to be effective to let people know aesthetics of ecological functions.

In this situation, Eaton (1990) proposed to use *metaphors*, which has a shared meaning. Unlike the artistic approach, use of metaphors, which employ old expressions in new ways, is reliable in establishing communication between sustainable design and people (Eaton, 1990). By using metaphor, it is possible to make unfamiliar sustainable design to stand for *something else*, which is more familiar to the public (Mozingo, 1997). In a similar manner, Nassauer (1992) proposed to use conventions of landscape appearance "to label ecological functions" (p. 246). A priority of these authors is to employ and extend a conventional vocabulary of current environmental design practice to make people aware of underlying ecological processes in sustainable design.

A slightly different perspective is brought forward by Wood (1988). He criticised a guideline for visual resource management by the US federal government for its intention to conceal ecological reality with expected images or "illusions." He then appealed that design practices should bring out the truth about what we are doing with the environment. Wood's approach is a good but bitter medicine for making us aware of our responsibility (Nassauer, 1992). However, it may not be suitable for achieving the goal of ecological aesthetics, because just revealing the ecological reality in a blunt manner is unlikely to bridge the gap between aesthetics and sustainability.

The difference in opinions among these authors seems to suggest that there is a dilemma between fostering aesthetic values of a society and revealing the ecological reality. It is perhaps because the current cultural values do not keep up with ecological necessity of the environment (Rapoport, 1994). It can be argued that it is a time of transition from current picturesque aesthetics to ecological aesthetics. Several design attempts have already been made to merge aesthetics and sustainability (e.g., Howett, 1987; Mozingo, 1997; Nassauer, 1997a). Although a consensus as to the way to bridge sustainability and aesthetics is yet to be made, the studies cited above have pointed some possible directions of sustainable design to achieve the transition to ecological aesthetics.

Empirical studies

There are at least two empirical studies addressing environmental preference for sustainable design. Thayer and Freeman (1987) investigated people's preferences for wind energy developments (WEDs) in northern California. They found that the WEDs are preferred somewhat (mean preference rating was 3.4 on the scale from 1 to 5). However, the participants' responses were neutral or negative on the scales of beauty and attractiveness. In the study, participants were classified into "like" and "dislike" groups, then their impressions for the WEDs measured by semantic differential items were compared. The researchers reported that those who liked the WEDs found them efficient, interesting, and appropriate, while those who did not like them emphasised their negative visual attributes such as clutter and ugliness. From the results, they suggested that the two groups were responding to different salient characteristics of the WEDs. They also documented that participants' understanding regarding the WEDs, such that some wind turbines are not operating even in a windy day, or that wind turbines are used for tax sheltering purposes, had some impact on their affective responses. Although the study suggested that the cognitive component plays a certain role in preferences for the WEDs, the extent to which cognition influences preference was not examined empirically in their study.

Another empirical study was conducted by Nassauer (1993). She studied preferences for various types of vegetation in a front yard of a suburban house typically found in the north-eastern part of the United States. Stimuli ranged from a conventional lawn to ecologically sound native plant garden with several "mixed" gardens in between. The findings of the research indicated that participants of the study most liked a conventional mown turf, which is not particularly sustainable because of its failure to provide biodiversity and intensive use of water and chemicals. However, the participants also showed high preference for a yard in which 50 percent of the lawn is replaced to plants indigenous to the oak savanna, which are more sustainable than a conventional lawn.

Based on the results, Nassauer reported that perceptions of care and neatness are highly associated with participants' preferences for the gardens. She also found that those who have more knowledge on ecology tend to like the native plant gardens, while those without ecological knowledge tend to prefer the conventional lawn. Her study demonstrated that although cultural expectation is still a significant factor in preferences for a residential garden, it is possible to achieve ecologically healthy as well as preferred landscape. The important implication of the study is the contribution of perceived human care in preference. This signifies that sustainable design can employ "design cues" that display active human care and stewardship to help link sustainability and aesthetics. The study also suggested the effects of environmental knowledge on preferences for sustainable design.

The above two empirical studies indicate that some people prefer some types of sustainable design. Although it has been suggested that environments managed for sustainability would not be preferred (e.g., Parsons, 1995), the two studies showed that it is not necessarily the case. However, they have dealt with a only a few types of sustainable design. As elucidated in the previous chapter, there are a wide variety of measures in sustainable design. In order to have comprehensive understanding of people's perceptions of sustainable design, it is important and worthwhile to investigate preferences for various types of sustainable design other than wind turbines and native plant gardens.

Further investigation is also necessary to explore other factors that are likely to affect preferences for sustainable design. The above two studies suggested the role of cognitive components and perception of care in the formation of preference judgements. However, the above studies have not examined *a degree of sustainability* as a factor influencing preferences. Obviously, achieving sustainability in the environment is of central importance to sustainable design. Thus, as discussed in this chapter, people's evaluation of sustainability can be considered to have some impacts on their preferences for sustainable design. The above studies are also silent about the effect of environmental attitudes and culture on preference. The current study has presented discussions that suggest the importance of these factors in perception of sustainable design. Empirical research is necessary to investigate these issues to have a better understanding of preferences for sustainable design.

The main research question of the empirical part of this thesis is the relationship between preferences for sustainable design and people's cognitive evaluation of sustainable design. Several issues related to this question such as the influences of environmental knowledge, attitudes, and culture will also be explored empirically. The next chapter delineates research questions and hypotheses as well as research methods to address them.

Chapter Five

RESEARCH METHODS

Research Questions and Hypotheses

The thesis investigated six research questions related to preferences for sustainable design. The first three questions are mainly exploratory, and aim to identify perceptual factors influencing preferences for sustainable design. The last three questions are more confirmatory, and examine seven hypotheses constructed based on previous research in the field of EBS and the theoretical model put forth in this thesis. This section discusses each of these questions and associated hypotheses.

The first research question examined empirically whether and to what degree people prefer sustainable design. As reviewed earlier, some conflicting ideas exist regarding people's preference for sustainable design. On one hand, some researchers point out that environments managed for sustainability tend to be less attractive and less preferred than environments managed for aesthetics or recreation (e.g., Mozingo, 1997; Parsons, 1995; Schulhof, 1989). Rapoport (1994) mentioned that the current vocabulary of sustainable design is not congruous with preferred environmental attributes. On the other hand, it has been found that the majority of people are highly concerned with environmental issues (e.g., Arcury & Christiansen, 1990; Dunlap et al., 1993). It is possible to hypothesise that people prefer sustainable design, because it helps resolve or mitigate environmental problems, and ultimately contributes to people's well-being. As S. Kaplan (1987) argued, we tend to prefer a setting in which we are likely to survive. However, because of the scarcity of empirical research in this field, it is not known which hypothesis is more likely. In order to fill this gap in the previous research, this study first examines the relationship between people's preferences for various types of sustainable design and their contribution to environmental sustainability. Thus, the research question comes down to the correlation between preference and degree of sustainability. To answer this question, it is necessary to identify the degree of sustainability a particular sustainable design achieves. It would be interesting to examine the relationship between preference and the physical degree of sustainability. However, there is no agreed measurement method of the physical degree of sustainability because of the highly complex and holistic nature of sustainability (Bell & Morse, 1999; Farrell & Hart, 1998). Thus, the present study employs the notion of the perceived degree of sustainability assessed by individuals. As discussed in the previous chapter, this variable is called "evaluation of sustainability" or "cognitive evaluation." A measurement method for this variable is delineated later in this chapter.

The second question was to understand underlying perceptual dimensions of sustainable design through the classification of sustainable design examples. As discussed in the previous chapter, sustainable design can be achieved in many different ways. It is possible to assume that people perceive sustainable design differently depending on its characteristics such as methods used, the way the design is presented, the degree of maintenance, and cultural familiarity. It can be argued that preference for and evaluation of a certain sustainable design are dependent on these characteristics. In this research question, the study attempted to categorise stimuli of sustainable design into a few clusters based on participants' preference and their cognitive evaluation. The study then sought to interpret characteristics, which differentiate one cluster from the other. Characteristics extracted in this process can be understood as the criteria people employ to differentiate sustainable design. Another purpose of the classification was to use the clusters formed in this process as units for further analyses. In some of the following research questions, analysis was conducted based on empirically clustered groups of examples rather than on individual and perhaps idiosyncratic examples.

The third question was the identification of salient dimensions in the perception of sustainable design. In addition to preference, the participants were asked to indicate their impressions of sustainable design on nine semantic differential scales. The detail of the scales will be discussed later. Using the ten semantic differential items, the third research question aimed at finding people's perceptual pattern for sustainable design examples. Similar to the second question, this research question tried to identify factors involved in people's perception of sustainable design. Both questions are interested in qualities of sustainable design perceived by individuals. However, since the third question specifically deals with impression items, the focus of the question is more on the way people perceive or conceive of sustainable design.

The fourth research question was to examine the effects of different levels of information concerning sustainability on people's cognitive evaluation of and preferences for sustainable design. It was expected that participants would not be familiar with examples of sustainable design presented as stimuli in the study. Since some of the examples do not show any visual clues which would suggest its degree of sustainability, it was presumed that participants' evaluation of sustainability about the stimuli would not necessarily be "correct." The following two hypothetical causal relationships were examined in the study:

H_1: Those who received information regarding sustainability are likely to evaluate sustainable design more positively than those who did not receive information.

H_2: Those who received information regarding sustainability are likely to prefer sustainable design more than those who did not receive information.

In addition to these hypotheses, the thesis was also interested in examining what forms of information are more effective in altering cognitive evaluation of and preference for sustainable design. Two different types of information that people may receive in a daily situation were given to participants to investigate their effectiveness in influencing their perception of sustainable design.

The fifth question of the study involved the construction and testing of hypothetical models to account for preferences for sustainable design using evaluation of sustainability, environmental knowledge, and environmental attitudes as predictors. The model was constructed based on a set of hypotheses described below:

H_3: Evaluation of sustainability influences preference for sustainable design.

H_4: Environmental knowledge influences the evaluation of sustainability.

H_5: Environmental attitudes influence preference for sustainable design.

H_6: Environmental knowledge and environmental attitudes are correlated with each other.

The previous chapter presented discussions from the literature in EBS that supported these hypotheses. The fifth research question is an extension of the fourth question. Namely, the fourth question addresses the effects of information on evaluation of sustainability and preference but not the direct relationship between evaluation and preference. In this fifth research question, through the model that incorporates constructs considered to have some influence on preference and evaluation of sustainability, the thesis aimed to assess to what degree cognitive evaluation influences preference.

The sixth and final question of the research was cultural comparisons. Japanese and Australian participants were compared in terms of their preferences for and cognitive evaluation of the sustainable design examples. As will be seen, it is not possible to claim that samples used in this study represent the general Japanese and Australian public. However, differences between the two samples are of interest in the research. Cultural differences may also offer an interesting opportunity to examine the relationship between affect and cognition in preference. Ulrich (1983) noted that cognitive reactions can vary widely depending on cultural factors, whereas affective reactions are more common across cultures. Since preferences for sustainable design are expected to depend somewhat on cognition, it is possible to hypothesise as follows:

H_7: If cultural differences in preferences for sustainable design between Japanese and Australian respondents exist, they are due to differences in cognitive evaluation of sustainable design.

Based on the discussion so far, it is possible to summarise the hypothetical relationships examined in this thesis. Figure 12 illustrates the constructs explored in this study and the hypothetical relationships between the constructs. Numbers associated with lines in the diagram (H_1 to H_7) refer to the hypotheses discussed in this section. Although Figure 11 shows cultural influences on environmental knowledge and attitudes, these relationships will not be discussed in the present study.

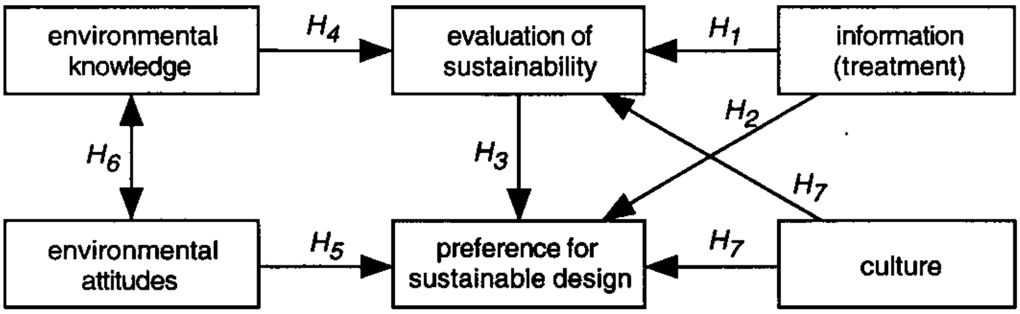


Figure 12. The constructs and hypotheses examined in this study.

Research Design

In order to approach the research questions stated above, this study employed a multi-group post-test only experimental design. Figure 13 is a notational diagram illustrating the research design. Respondents were randomly assigned to three groups: one control group and two treatment groups. The treatment groups were given two different levels of information regarding sustainability (X_1 and X_2), while the control group received no such information. Details of the treatments will be discussed later. After randomisation and the treatments, participants in each group were asked to indicate their preferences for and cognitive evaluation (O_0, O_1, and O_2) of photographs of sustainable design examples.

Because of the random assignment of respondents, the three groups may be considered statistically equivalent. This arrangement makes it possible to judge that differences between the

R —— —— O_0

R —— X_1 —— O_1

R —— X_2 —— O_2

R: random assignment of respondents to groups
X: treatment (information)
O: observation (preference and cognitive evaluation)

Figure 13. Notational diagram of post-test only experimental research design.

groups in preference and evaluation of sustainability are caused by the treatments. Random assignment provides protection from many common rival explanations that may confound research findings (e.g., Campbell & Stanley, 1963).

Data Collection

Population and sample

The study was interested in ordinary people's perception of sustainable design. Environmental problems involve all kinds of people, and sustainable design discussed here covers a wide range of approaches and settings. For this reason, there is no specific group of people to be investigated as a population of the study. Thus, ideally, a sample of the study should include as many kinds of people as possible. However, at the same time, the study employed experimental research design that entailed a highly controlled setting. The study required that data be collected from participants in one place because of logistic and financial restrictions. It was thus very difficult to collect data from people varying widely in age, occupations, and sociocultural backgrounds. Due to these reasons, undergraduate college students in Japan and Australia were chosen as participants for the study. Participants' fields of study included social science (psychology, health science, and education), environmental design (architecture and landscape architecture), engineering/science. Previous research has found that college students' preference can be regarded as representative of the general population (Daniel & Boster, 1976, cited in Gobster & Chenoweth, 1989).

Two hundred and forty-nine undergraduate students from four universities in Japan and two universities in Australia participated in the survey. Data were collected in May and December 2000 in Japan, and in August and November 2000 in Australia. Data from 14 respondents were not used for analysis. Eleven of them (1 from Waseda and 10 from Melbourne) were excluded because they turned out to be postgraduate students. Three (1 from Tohoku, 1 from Kyushu, and 1 from Sydney) responses were also discarded because a major part of their questionnaires were left unanswered. Data analyses were conducted for the rest of the 235 participants. Table 1 shows participants' fields of study and the number from each university in the initial sample and the final sample. Table 2 shows demographics of the participants in the final sample.

Since the study intended to examine the effect of information on preference and cognitive evaluation, those who are very knowledgeable about environmental issues were considered

Table 1

Participants of the Research in the Initial and Final Sample

University	Fields of study	Initial sample	Final sample
Kyushu University	Education	58	57
Tohoku University of Art & Design	Architecture	23	22
Tokyo Institute of Technology	Engineering/Science	21	21
Waseda University	Health Science	29	28
Japan Total		131	128
University of Melbourne	Landscape Architecture	33	23
University of Sydney	Architecture	20	20
University of Sydney	Psychology	65	64
Australia Total		118	107
Total		249	235

not suitable as respondents. For this reason, first-year undergraduate students were mainly chosen. As Table 3 indicates, this is especially the case in the fields of environmental design and engineering/science. At the University of Sydney, participants in psychology were given a credit by participating the survey. In the other venues, data collection sessions were conducted within the time frame of classroom lectures or design studios.

Table 2

Demographics of the Participants

		Japan	Australia	Total
Gender	Male	54	30	84
	Female	71	73	144
	Unknown[a]	3	4	7
	Total	128	107	235
Age	Range	18 – 26	18 – 41	18 – 41
	Mean (*SD*)	19.0 (1.32)	19.9 (4.03)	19.4 (2.91)

[a] No response in gender.

Table 3

Participants' Fields of Study and Academic Year

Field of study	1st	2nd	3rd	4th/5th	Unknown	Total
Environmental design	60	1	1	1	2	65
Social science	117	20	6	1	5	149
Engineering/Science	21	–	–	–	–	21
Total	198	21	7	2	7	235

Stimuli

Eleven colour photographs (127 mm x 88 mm) of outdoor scenes were presented as stimuli to the participants. Among them, nine were examples of sustainable design, and two were examples of unsustainable design. The latter two were also examples of environments that are designed to fulfill cultural expectations of people. These two were included in the stimuli to make a comparison with the sustainable design examples. Table 4 describes the characteristics of each design example. These examples were chosen to have a wide variety of environmental design types to approach sustainability. They ranged from ecological to technological, and their settings spanned from natural to urban. These examples also demonstrated a wide latitude in its "visibility" of sustainability. Namely, some examples were easily recognisable as sustainable, while others were difficult to be identified as sustainable design.

Due to the limited amount of time, all the participants at Kyushu University (n = 57) rated only eight photographs. The following three design examples were excluded at this university: the pond, solar house, and commercial complex.

The photographs were taken on a sunny day in summer or fall with a 35 mm lens and colour print film (ASA 100). Because of the difficulty in locating suitable sustainable design ex-

Table 4

Description of the Design Examples

No	Design example	Description
1	Windmill	modern wind turbines for energy production
2	Wetland	to process storm water of nearby neighbourhoods
3	Pond[b]	rehabilitated to improve a surrounding ecosystem
4	Solar house[b]	roof covered entirely with solar panels
5	Drainage	natural drainage to process rain water on-site
6	Sod covered house	walls and roof covered with soil and plants
7	Commercial complex[b]	built with reused and recycled materials
8	Research centre	equipped with latest energy-saving technologies
9	Apartment	designed to utilise natural energy and microclimate
10	Suburban house[a]	suburban house on a large lot
11	Park[a]	conventional lawn

[a] Examples of unsustainable design.

[b] Examples not rated by the participants at Kyushu University.

amples, photographs of two examples, the pond and park, were scanned from books and printed with photographic quality.

In the data collection session, a title consisting of one or two words (shown in Table 4) was attached next to each photograph to clarify an object to be evaluated. However, the three houses in the examples were simply titled as "house" to avoid any influences from the words "sod covered," "solar," and "suburban." The photographs were presented to individual participants in the format of a photo booklet. In the booklet, each photograph was placed on the left side, while its title was printed on the right side. The order of the photographs was counterbalanced for about a half of the participants at each venue. The eleven photographs presented as stimuli are shown from Figure 14 to Figure 24. The images are the same size as the photographs shown to the participants.

Figure 14. Photograph 1 (Windmill).

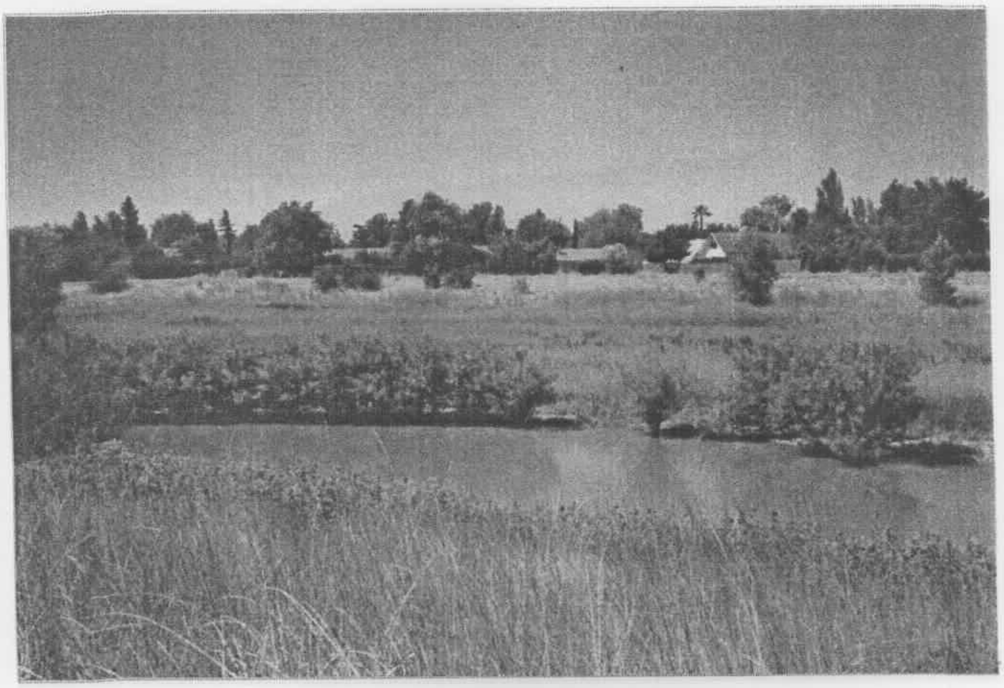


Figure 15. Photograph 2 (Wetland).

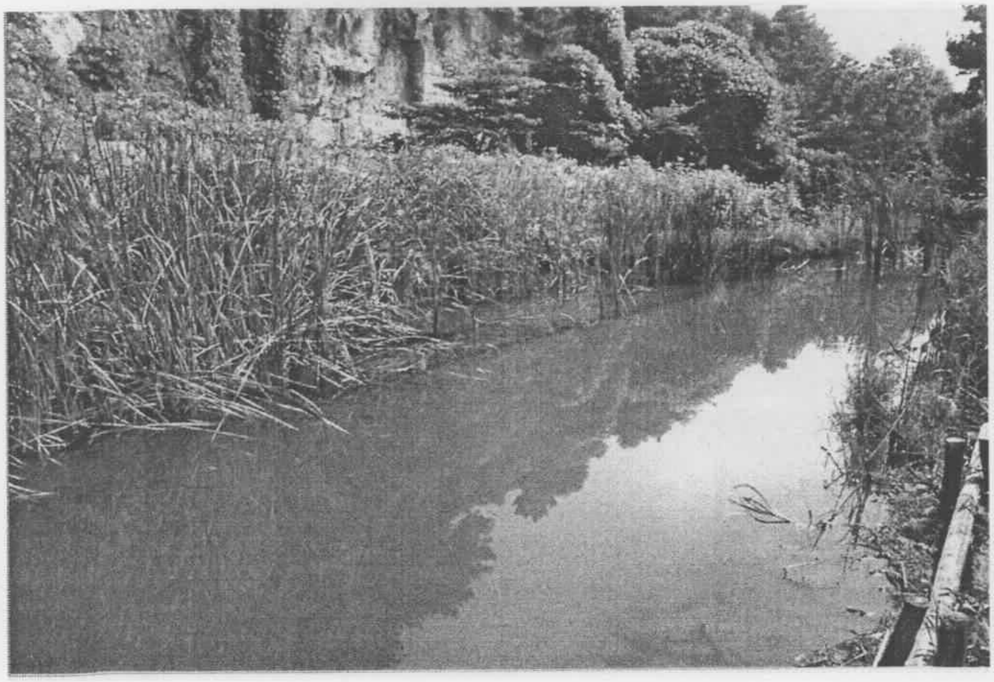


Figure 16. Photograph 3 (Pond).

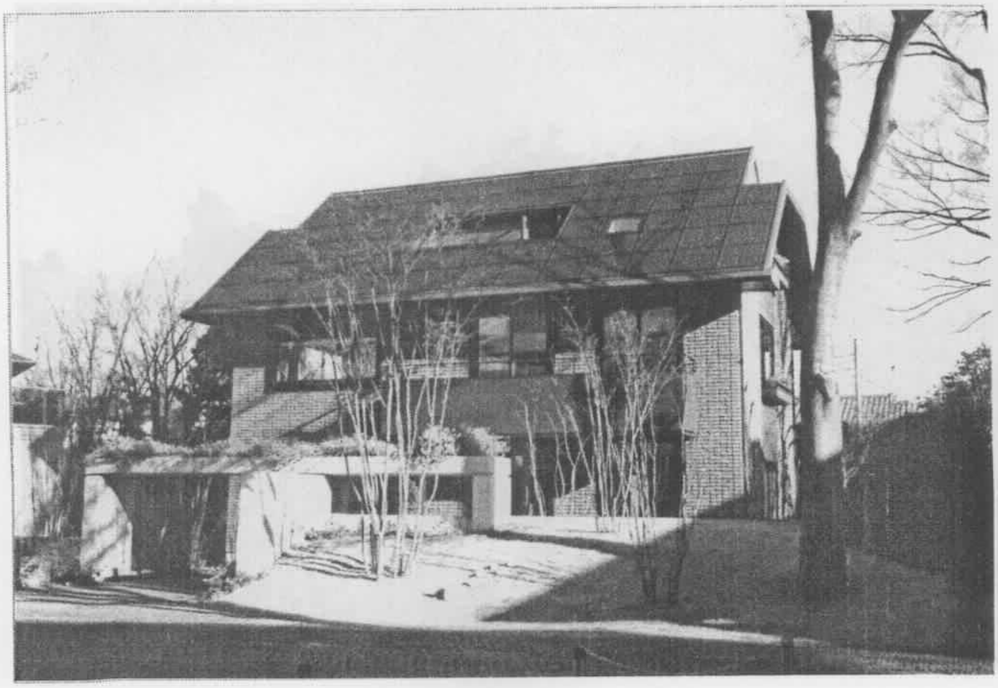


Figure 17. Photograph 4 (Solar house).

Figure 18. Photograph 5 (Drainage).

Figure 19. Photograph 6 (Sod covered house).

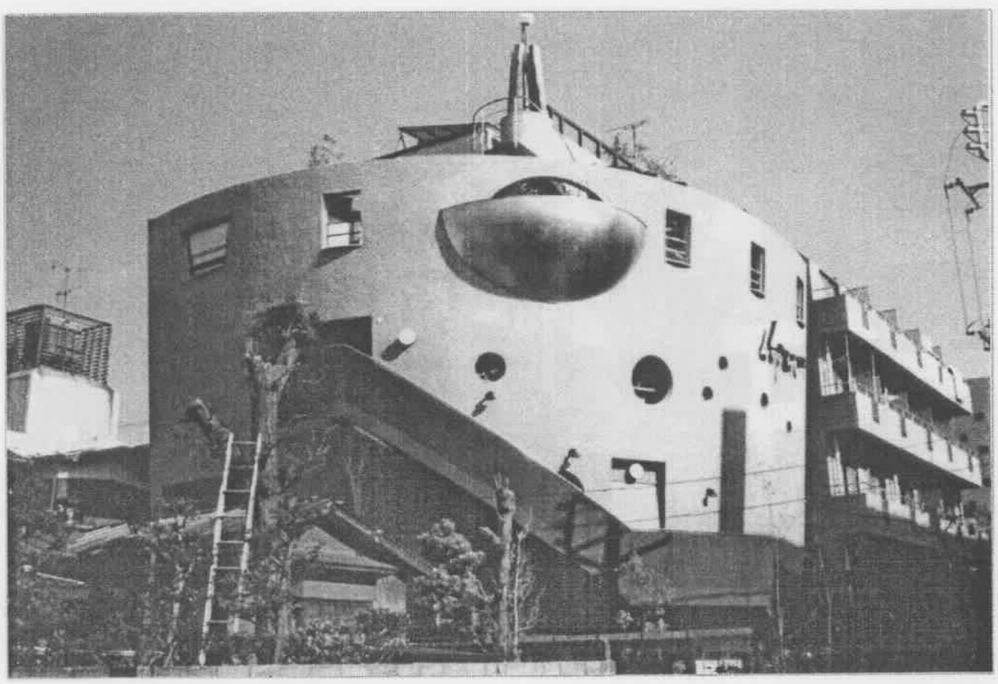


Figure 20. Photograph 7 (Commercial complex).

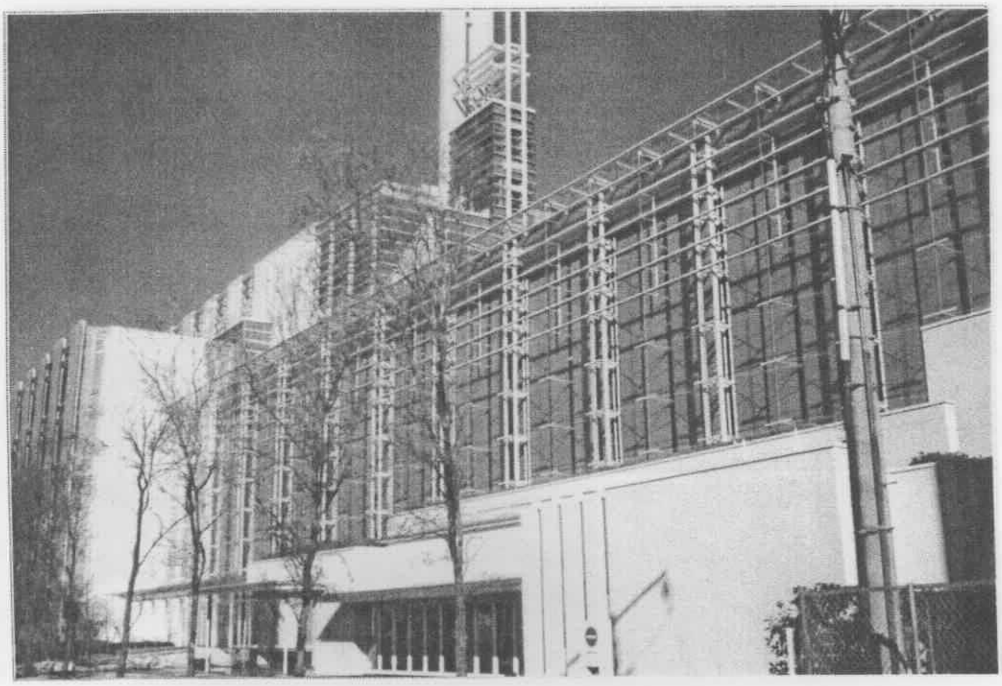


Figure 21. Photograph 8 (Research centre).

Figure 22. Photograph 9 (Apartment).

Figure 23. Photograph 10 (Suburban house).

Figure 24. Photograph 11 (Park).

Pilot tests

Small-sample pilot tests were conducted to select the most appropriate photographs. The first pilot study was conducted in November 1999 in Australia. Six undergraduate students in landscape architecture at the University of Western Sydney rated preferences for seven design examples: windmill, wetland, golf course, drainage, sod covered house, bike path, and suburban house. In this pilot study, two examples, the golf course and bike path, were judged inappropriate as stimuli. The golf course was considered unsuitable, because a post-survey interview with the participants disclosed that they reacted not to an image of a golf course but to the title "golf course." Some participants reported that they sensed the intention of the survey from the questionnaire and the set of photographs. It was suspected that the knowledge of purpose of the research let the participants to have a negative impression in the general idea of golf course. The bike path was also considered inappropriate, because this example was slightly different from the others. Namely, it is not the bike path itself but activities on the bike path (riding a bike instead of using a car) that contribute to sustainability. A few participants commented that they were not sure if they were to evaluate the bike path itself or activities associated with it. Although this type of activity is an important constituent of sustainability *in* the environment, it was considered that avoiding confusion in photograph rating tasks had a higher priority.

The second pilot test was conducted in March 2000 in Japan. Twelve students (undergraduate and postgraduate) majoring agriculture at Meijo University rated preferences for and cognitive evaluation of 11 design examples: windmill, wetland, drainage, sod covered house, suburban house, park, apartment, solar house, pond, commercial complex, and research centre. These design examples were the same as those used in the final data collection. In this pilot study, between one and three photographs for each design example were presented to examine the relative appropriateness of different photographs. It was found from a post-survey interview that photographs which contained two or more focal objects were difficult to judge in that preferences for and evaluations of those objects in a photograph often did not concur. For this reason, a photograph that has a dominant object in the centre was selected for each design example for the actual data collection. This pilot test confirmed that, as far as the selected photographs were concerned, the participants had no problem identifying the intended object and were not distracted by any extraneous elements that might influence preferences such as humans, large trees, conspicuous clouds, flowers, and birds.

Criticisms of using photographs

In studies involving evaluation of the environment, photographs and slides have been used quite often to represent actual environments (e.g., Balling & Falk. 1982; Herzog & Barnes, 1999; Hull & Revell, 1989). The use of photographs or some other surrogates allows researchers to collect data from a large number of people with less time and expense than in the field. However, there are some criticisms in the use of photographs as surrogates of actual environments. Two different types of arguments are involved in the criticisms: validity and reliability of using a photographic medium. This section discusses the two issues based on some empirical studies.

Validity. Validity discussed here is the "ecological validity." This can be defined as the agreement between on-site evaluation of the environment and evaluation based on photographs (Hull & Stewart, 1992; Palmer & Hoffman, 2001). The two modes of environmental evaluation can be different in several aspects. The on-site evaluation allows evaluators to move and explore the environment, while photograph evaluation is static and two-dimensional. Settings in which evaluation is made are also different between the two modes: actual experience of the environment versus experiment in a classroom setting. Nevertheless, many empirical studies have found high correlation between evaluation of photographs and on-site evaluation. For instance, Zube and Pitt (1981) compared scenic quality evaluation on-site and through photographs, and found a correlation coefficient of .93 between the two groups.

Stamps (1990) conducted a meta-analysis on comparison of preference ratings obtained by the two modes. Based on eleven studies that included more than 2,400 respondents, he reported a high correlation (r = .86) of preference between the two methods of evaluation. Furthermore, Kellomäki and Savolainen (1984) found that photographic evaluations of forest landscapes by those who visited the landscapes and those who did not visit showed a high degree of agreement (r = .96). The results from these studies suggest that people are capable of inferring a three-dimensional environment from two dimensional representation.

Hull and Stewart (1992) questioned the ecological validity of photograph usage for landscape evaluation. These authors pointed out that actual experience of the environment and evaluation of photographs in an experimental setting differ markedly in the following: purpose of evaluation, a sense of surprise associated with a sequence of the experience, and mood of person who experiences or evaluates the environment. However, these points Hull and Stewart (1992) made appeared to be more relevant to the experience of scenic landscapes. Although it is not known how people experience sustainable design, it is unlikely that the way people experience sustainable design and scenic landscapes are very similar. It is possible to argue that the sequence of experience and mood of a person do not play an important role in the experience of sustainable design. The purpose of evaluation appears to have some relevance also in the case of sustainable design. However, as will be discussed later, the participants were told that they would be asked to evaluate images related to environmental issues. Thus, the purpose of evaluation given in this research may be similar to a frame of reference people are likely to have when they are appraising sustainable design on-site. It appears, therefore, that the criticisms pointed out by Hull and Stewart (1992) are not applicable to the current study.

Another possible criticism is the "content validity" of using photographs. Content validity refers to the extent to which a test or measure "provides an adequate representation of the conceptual domain it is designed to cover" (Kaplan & Saccuzzo, 1997, p. 132). It is possible that comparing different photographs may be equal to comparing their photographic quality rather than their contents. It is known that preference is somewhat dependent on the formal and configurational quality of a stimulus such as complexity (e.g., Kaplan & Kaplan, 1982a; Ulrich, 1983; Wohlwill, 1976). However, on the issue of formal quality of stimuli, Stamps (1994) found that formal factors of photographs accounted for much less variance of preference than did the content of the photographs. Nassauer (1983) also reported that in non-scenic landscapes, subjects' responses to compositional factors of photographs tend to be relatively less important than their content. Thus, it seems safe to assume in this study that minor compositional differences of the photographs do not have much effect on participants' preference ratings.

It seems that the major difference between evaluation of scenic landscape and that of sustainable design is in the nature of images to be evaluated. On the one hand, photographs used in landscape evaluation are "scenes" often taken from a long distance. In these scenes, what will be focused is primarily the background, although unessential objects occasionally appear in the foreground. Respondents are requested to assess the scene in this case. On the other hand, the photographs employed in the current study had a main "object" to be evaluated in the centre of the foreground. The participants were instructed to evaluate the object rather than a scene. The titles attached to the photographs also helped isolate the object from its background. This way of framing the object along with its title appears to ensure content validity of the use of photographs in this study.

Reliability. "Reliable measurement" signifies that measurement scores do not vary significantly across time and across people (Kaplan & Saccuzzo, 1997). The former type of reliability can be checked with test-retest reliability, the latter type of reliability pertains to inter-rater reliability (e.g., Huck, 2000). To examine test-retest reliability, Hull and Stewart (1992) conducted the same landscape preference test twice with a period of 6 months between the two using the same participants and the same set of photographs. These researchers found a high degree of agreement between the two tests. The correlation coefficient between pre and post group mean scenic beauty ratings was .998, and a mean of the correlation coefficients of individual participants' ratings was .78.

Interrater reliability was considered irrelevant in the study, because it was expected that participants respond differently to photographs depending on their environmental knowledge, attitudes, cultural backgrounds, and other factors. In summary, evidence presented from the studies discussed here supports that the use of photographs as a means to measure people's responses to sustainable design is both valid and reliable.

Constructs, variables, and instruments

The following five constructs were included in this study: preference and impressions, evaluation of sustainability (cognitive evaluation), environmental knowledge, environmental attitudes, and culture. These variables were measured using a series of scales in a questionnaire-type instrument. Appendix A shows a sample questionnaire. In the following, the thesis discusses details of the variables and scales to measure them.

Preference and impression. Preferences for the design examples were measured on a single item of like–dislike on a 7-point bipolar scale in this study. In environmental preference research, preference is in most cases measured by a single item on a Likert-type scale (e.g., Hagerhall, 2000; R. Kaplan & S. Kaplan, 1989; Purcell, Peron, & Berto, 2001). "How much do you like . . ." is a typical way to phrase the question measuring preference (e.g., Herzog, 1984; Hudspeth, 1986). In other studies, researchers asked "how much you would like to live or to visit. . ." to measure respondents' preference (e.g., Balling & Falk, 1982; Lyons, 1983). Several other studies employed a bipolar scale of like–dislike (e.g., Nasar, Julian, Buchman, Humphreys, & Mrohaly, 1983; Nassauer, 1993; Thayer & Freeman, 1987). In this study, respondents' preferences were measured on a 7-point bipolar scale together with the other semantic differential items.

In addition to preference, impressions of each design examples were measured on a semantic differential scale. Nine pairs of adjectives included in the questionnaire were the following: interesting–boring, attractive–unattractive, natural–human made, uncluttered–cluttered, well maintained–not well maintained, efficient–inefficient, simple–complex, conspicuous–inconspicuous, and beautiful–ugly. The response format was a 7-point bipolar scale. These pairs were chosen from descriptors used in empirical studies of preferences for wind turbines by Thayer and Freeman (1987) and those for native plant gardens by Nassauer (1993). The wording was modified from the original scales to avoid sexist expressions. In the study of Thayer and Freeman (1987), they used other pairs of adjectives: old fashioned–futuristic, inappropriate–appropriate, and disorganised–organised. Nassauer's study (1993) also employed good care–poor care in addition to the above. These pairs of adjective were not included in the present study, because they were considered redundant or not applicable to the research questions and stimuli presented.

Evaluation of sustainability. Participant's evaluation of sustainability for each design example was measured with a scale consisting of six statements listed in Table 5. The scale is called the "Perceptual Sustainability Evaluation" scale. The items for this scale were first gathered from the literature on environmental sustainability. Items in the scale were elaborated in the process of interviews with four experts in the fields of architecture, construction management, landscape architecture, and resource management.[2] Then, the items and their wording were tested in the pilot study in Japan. The response format was a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree." Since the third item was negatively stated, it was reversed in the coding process. Means of the responses to the six items were calculated and used as an evaluation score for each participant. A higher score

2. Experts from Shiga Prefectural University (architecture), the University of Tokyo (construction management), the University of California, Davis (landscape architecture), and Australian National University (resource management) reviewed the Perceptual Susutainability Evaluation scale for face validity.

Table 5

Items in the Perceptual Sustainability Evaluation Scale

1. (Example name) in this photograph makes use of natural energy.
2. (Example name) in this photograph is constructed with low impact on the environment.
3. (Example name) in this photograph has negative environmental effects on surroundings.
4. (Example name) in this photograph accompanies human activities caring for the environment.
5. (Example name) in this photograph requires little energy to maintain.
6. (Example name) in this photograph raises people's awareness toward the environment.

signifies that a participant considered a design example sustainable.

Several items were dropped from the scale during the process of the pilot study. First of all, the idea of biodiversity was not included in the scale from the beginning. Although biodiversity is an important criterion for sustainability, it was foreseen that biodiversity of a certain environment cannot be assessed from its photograph. The item related to recycling of resources was discarded after the pilot study. Although recycling and reusing of resources are quite effective in reducing environmental impacts and resource consumption, the pilot test found it very difficult to evaluate this aspect from a photograph. The expert in landscape architecture stressed that the rate of resource use should not exceed that of resource regeneration. This item, however, was excluded from the scale due to the difficulty of assessing it from a photograph.

As discussed in the above, the face validity of the Perceptual Sustainability Evaluation scale was confirmed in the interviews with the experts. However, the lack of the items mentioned above in the scale may suggest that the scale does not represent the "actual" degree of sustainability. It should be stressed that the current study was interested not in the actual degree but in the perceptual degree of sustainability. Since the study was to investigate ordinary people's perception of sustainable design, perceived qualities related to sustainability are of central importance in the present study. As noted previously, the thesis focuses on the environment "as it is construed" rather than the environment "as it is." However, this does not necessarily mean that unperceivable qualities are totally irrelevant to the present study. It was conceived that making people become aware of unnoticed environmental qualities has an effect of changing their preferences for sustainable design. Information about sustainability, which is difficult to recognise from photographs, was provided to one group of respondents as a treatment.

The reliability (internal consistency) of the Perceptual Sustainability Evaluation scale was checked to make sure that the six items in the scale are measuring the same characteristic. Since the reliability of the scale was likely to depend on a stimulus to be evaluated with the scale, reliability was calculated for each design example. Table 6 reports Cronbach's alpha of the Perceptual Sustainability Evaluation scale for each of the design examples. An acceptable level of the reliability of a psychological scale is generally considered at 0.7 or higher at

Table 6
Reliabilities of the Perceptual Sustainability Evaluation Scale

No	Design example	No. of cases	Reliability (alpha)
1	Windmill	227	.722
2	Wetland	223	.688
3	Pond	170	.630
4	Solar house	169	.852
5	Drainage	226	.800
6	Sod covered house	223	.763
7	Commercial complex	160	.837
8	Research centre	223	.855
9	Apartment	228	.824
10	Suburban house	224	.806
11	Park	227	.862
	Average	–	.785

the early stages of research (Nunnally, 1978). As shown in the table, the reliabilities were greater than 0.7 except for two instances: the wetland and pond. It is to be noted that both examples rely on ecological functions to approach sustainability. As mentioned previously, ecological functions are quite often invisible to human eyes (Nassauer, 1992). It can be argued that this "invisibleness" may have induced more uncertain responses to the items in the scale. Measures of internal consistency basically depend on correlation between scores of one half of the scale and those of the other half (Huck, 2000). Thus, a reliable scale, in which items in the scale measure the same underlying construct, should indicate a high correlation between two halves of the scale. In this sense, it would be possible to interpret that a low reliability, or a low correlation between two halves of a scale, might be caused by many uncertain responses from respondents. It could be then argued that the inherent quality in ecological sustainable design would have contributed to lower reliabilities in these two examples. Since the average reliability of all the cases was well above 0.7, the Perceptual Sustainability Evaluation scale was considered reliable enough to measure participants' evaluation of sustainability.

Environmental knowledge. Environmental knowledge in the current study refers to participants' understanding of general environmental issues. A ten-item scale devised in a study by Kaiser et al. (1999) was adapted to measure environmental knowledge. The items included in the questionnaire are shown in Table 7. Since one item in the original scale was specifically about the environment in Europe, the item was excluded. Thus, the scale used in the present study had nine items. For the response format, a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree" was used. A higher score signifies that the participant had more knowledge on general environmental issues.

Reliability analysis was conducted for the scale. Cronbach's alpha for all the items was .629. Considering the criterion suggested by Nunnally (1978), the reliability seemed relatively low. It appeared that many participants were confused by the questions regarding interde-

Table 7

Items in the Environmental Knowledge Scale

1.[a]	All living beings (micro-organisms, plants, animals, and humans) are interdependent with one another.
2.	Poisonous metals are introduced into the food chain, for instance, via ground water.
3.	A change in climate caused by increased levels of CO_2 in the atmosphere is called the greenhouse effect.
4.	Poisonous metals remain in the human body.
5.	The world climate will probably massively change if CO_2 continues to be emitted into the atmosphere in as huge amounts as it is now.
6.	Melting of the polar ice caps may result in a flooding of shores and islands.
7.	A reduced number of species may interrupt the food chain, affecting some subsequent species in the chain.
8.	Fossil fuels (e.g. gas, oil) produce CO_2 in the atmosphere when burned.
9.[a]	Ozone near the ground may cause respiration problems.

[a] Items not used for analysis.

pendence of all the species and the ozone layer (items 1 and 9). Dropping these items, the reliability of the scale was .687. Thus, in order to have a higher reliability, environmental knowledge was measured on a 7-item scale.

Environmental attitudes. Participants' environmental attitudes were measured on a 12-item scale called New Environmental Paradigm (NEP) designed by Dunlap and Van Liere (1978). The items included in the scale are shown in Table 8. For the response format, a 7-point Likert-type scale ranging from "strongly disagree" to "strongly agree" was used. Four negatively stated items (No. 2, 9, 10, and 12) were reversed in the coding process. A higher score in the NEP scale signifies more ecologically sound and proenvironmental attitudes.

There are other scales used in the literature to measure people's environmental attitudes. They include the Ecological Attitude Scale by Maloney and Ward (1973), its revised form by

Table 8

Items in the New Environmental Paradigm (NEP) Scale

1.	When humans interfere with nature, it often produces disastrous consequences.
2.	Humans were created to rule over the rest of the nature.
3.	There are limits to growth beyond which our industrialized society cannot expand.
4.	Humans are severely abusing the environment.
5.	To maintain a healthy economy, we will have to develop a "steady-state" economy where industrial growth is controlled.
6.	Humans must live in harmony with nature in order to survive.
7.	The earth is like a spaceship with only limited room and resources.
8.	The balance of nature is very delicate and easily upset.
9.	Humans have the right to modify the natural environment to suit their needs.
10.	Plants and animals exists primarily to be used by humans.
11.	We are approaching the limit of the number of people the earth can support.
12.	Humans need not adapt to the natural environment because they can remake it to suit their needs.

Maloney, Ward, and Braucht (1975), and the Environmental Concern Scale by Weigel and Weigel (1978). These scales were not adopted because they are primarily concerned with the issues of pollution and environmental conservation. The NEP scale was chosen in this research because the scale has been tested many times and found to reliably measure people's beliefs and attitudes about human-environment relations (Fransson & Gärling, 1999; Stern, Dietz, & Guagnano, 1995). The reliability and validity of the NEP scale have been checked and documented in several studies (e.g., Arcury, 1990; Dunlap & Van Liere, 1978, Noe & Snow, 1990; Scott & Willits, 1994).

Culture. Culture is another construct in the study. Since Australia is a multinational country, it has many kinds of people who differ in their way of life, value structure, and their views regarding the relationship between people and the environment. A survey by NSW Environment Protection Agency (1997) found that people from a non-English speaking background in Australia were somewhat different from people from an English speaking background in terms of environmental knowledge and attitudes. In this sense, using ethnic difference may be a better way to conduct cultural comparisons. However, the number of Australian participants whose first language was not English was rather small ($n = 30$). Cultural comparison in this study was conducted with two-way ANOVA, in which the effects of the treatments were also assessed. This means that one culture group was further partitioned into several groups according to the treatments. Since this subsample ($n = 30$) is too small to subdivide, Japan and Australia were considered to represent different cultures in the research.

Treatments

Participants in the experiment were randomly assigned to three experimental groups and given different treatments. The two treatment groups (TG1 and TG2) received varying levels of information regarding sustainability, while the control group (CG) received no such information. The types of information provided were specific (TG1) and general information (TG2). Table 9 indicates the number of participants in each group at each university.

Table 9

Number of Participants in the Control and Treatment Groups

Group (Type of Information)	CG (None)	TG1 (Specific)	TG2 (General)	Total
Kyushu University	19	19	19	57 [a]
Tohoku University of Art & Design	12	10	– [b]	22
Tokyo Institute of Technology	11	10	– [b]	21
Waseda University	8	12	8	28
Japan Total	50	51	27	128
University of Melbourne	7	8	8	23
University of Sydney	28	27	29	84
Australia Total	35	35	37	107
Total	85	86	64	235

[a] Participants evaluated only 8 photographs.

[b] TG2 was not given to these universities, because the initial analysis found very little effect from this treatment.

The participants in CG answered the questionnaire while looking at just the photographs with their titles. In addition to these, the respondents in TG1 were provided detailed information about functions and effectiveness of each design example. The information, which was roughly 100-words long for each example, described in simple terms in what way each design example works to help resolve environmental problems and approach sustainability in the environment.[3] Thus the participants in TG1 were expected to have enough information to make a correct evaluation of the degree of sustainability of each design example. The information for each example was printed on a sheet of paper (the same size as the photograph), and placed next to each photograph in the photo booklet. Appendix B shows the content of the information for TG1.

The participants in TG2 were asked to read general information about today's environmental problems. The general information, which was about 500-words long, contained descriptions of problems in the current environment, their causes, and general strategies for a sustainable future.[3] It was hypothesised that the general information would not influence participants' cognitive evaluation, because the information did not provide any hints that would suggest functions of the design examples. However, it was postulated that highlighting a predicament of today's environment may influence participants' environmental attitudes (Hausbeck et al., 1992), which in turn may lead to a change in preferences for sustainable design. Appendix C shows the content of the information for TG2.

The two treatments in the experiment mirror in general the information people may receive in real-life situations. The specific information in TG1 can be equivalent to the information one may obtain by participating in educational activities such as seminars related to environmen-

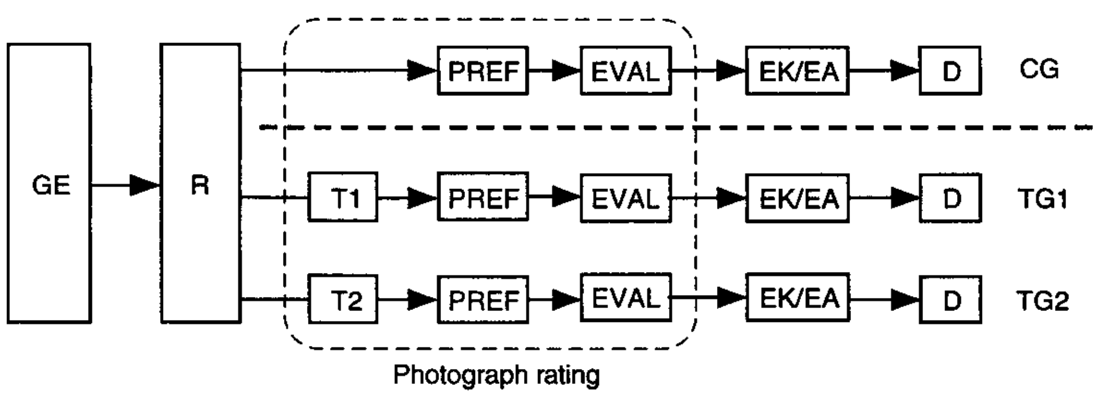
3. The treatements TG1 and TG2 were tested in the pilot studies discussed before. Post-survey discussion with respondents confirmed that they understood the content of the information. Initial information for TG1 was shortened so as to reduce the time to read the information.

tal issues or guided tours in facilities or landscapes aiming to improve the quality of the environment. Brochures and booklets from environmental agencies also seem to contain a similar type of information. The general information for TG2 is expected to be analogous to the information one can get from the mass media. Slogans shown in newspapers and public media, similar to the general information provided, tend to be brief and include only general information. The findings of this research, then, can provide some insights into the effects of these interventions in changing people's perceptions of sustainable design.

Procedure

A data collection session consisted of three stages: (1) explanation of purposes including informed consent, (2) randomisation of participants, and (3) administering the questionnaire that included photograph rating tasks, environmental knowledge and attitudes measurement, and demographic data collection. Figure 25 depicts the procedure of data collection.

The general purpose of the research was explained to the participants in the first place. A



GE: General explanation
R: Randomisation to groups
T1, T2: Treatments

PREF: Preference
EVAL: Evaluation of sustainability
EK/EA: Environmental knowledge & attitudes
D: Demographic data

Figure 25. Procedure followed in data collection.

"participants information statement" (Appendix D) was given to each of them to explain the purpose. It is known that preferences are dependent on the evaluation purpose a person has in mind (e.g., Hull & Revell, 1989; Hull & Stewart, 1992; Ward, Snodgrass, Chew, & Russell, 1988). For instance, preference for a certain landscape by travelers versus farmers can be quite different because of the difference in evaluation criteria. For this reason, to provide a similar frame of reference, the participants were informed that they would be asked to evaluate some photographs related to environmental issues. One possible problem incurred by disclosing the purpose of the research was that participants may sense a hypothesis of the study. Knowledge of the expectation of a researcher may influence responses of participants. However, this disclosure was necessary to ensure the equal condition between the control and treatment groups, for it was only the treatment groups that received information about environmental issues before answering the questions. In addition, the pilot tests found that participants became vaguely aware of the purposes of the study anyway through the questionnaire and the stimuli. Along with the participants information statement, a consent form (Appendix E) was given to all the participants to assure their rights regarding their participation in the study.

In the next step, the respondents were randomly assigned to three treatment conditions. Each participants' month of birth or student number was used for randomisation. Each participant then received the questionnaire and the photo booklet which included the photographs of the design examples. The photo booklet for CG (no information) enclosed only the photographs with their titles, while that for TG1 (specific information) and TG2 (general information) also included respective information sheets. All the participants were then asked to read instruction at the top of the questionnaire and to start answering the questions. The questionnaire for TG1 advised respondents to read the specific information attached next to each photograph as they went through the questions. The questionnaire for TG2 instructed respondents to read the general information, which was placed at the beginning of the photo booklet, before answering any questions.

The first task of each participant was to rate each photograph on the 10 sematic differential items including preference. Then, they were asked to evaluate the same photographs on the six-item Perceptual Sustainability Evaluation scale. In the third part of the study, the participants were asked to mark their responses to 21 statements that include the scales of environmental knowledge and attitudes. Since the both measurements used the same response format, the items of the scales were mixed into one series of questions. In the final part, participants' age, gender, fields of study, academic year, and first learned language were recorded.

The order of the photographs and that of the items in each part of the questionnaire were counterbalanced for a half of the participants in every treatment at each venue. No significant differences were found in preference ratings, evaluation scores, environmental knowledge, and attitudes due to the different order of the photographs and items. It took approximately 25 to 35 minutes to complete the questionnaire for CG and TG2, and 35 to 45 minutes for TG1. The entire data collection session was between 45 and 55 minutes long. There were no complaints about the study or the duration of data collection, and no respondents refused to participate in or left midway through the research.

Data Analysis Methods

Since Likert-type and semantic differential scales were used for data collection, the measurement level of the data in the study was ordinal. Therefore, strictly speaking, it may not be appropriate to use parametric statistics for which an interval or ratio level is assumed for application. However, statisticians argue that many parametric techniques are robust to violations of assumptions of measurement levels (e.g., Jaccard & Becker, 1997). Also, Dawes and Smith (1985, cited in Judd, Smith, & Kidder, 1991) found from their empirical investigation that ordinal data may be treated as interval data if the relationships are essentially linear. Furthermore, the literature of EBS provides many instances in which parametric statistics such as factor analysis (e.g., Gobster & Chenoweth, 1989; Stern et al., 1995), analysis of variance (e.g., Herzog, 1989; Stamps & Nasar, 1997), path analysis (e.g., Rochford & Blocker, 1991; Syme, Beven, & Sumner, 1993), and structural equation modeling (e.g., Bratt, 1999; Kaiser et al., 1999) are performed on data of the ordinal level. Following the precedents of these studies, this study also employed parametric statistics.

The data set has some missing data, because a slightly smaller number of design examples was evaluated at Kyushu University (*n* = 57). The total number of participants who evaluated all 11 design examples was 178. This data set that includes responses to all the design examples was named Data Set A (*n* = 178). This data set was employed when all 11 design examples need to be included in analysis. The data set that includes all the participants was titled Data Set B (*N* = 235), and was used when all the participants or a larger number of participants was required for analysis. However, this data set includes responses from only eight stimuli. The numbers of participants in the control and treatment groups in Data Set A are shown in Table 10.

Table 10

Number of Participants in the Control and Treatment Groups in Data Set A

Group (Type of Information)	CG (None)	TG1 (Specific)	TG2 (General)	Total
Japan	31	32	8	71
Australia	35	35	37	107
Total	66	67	45	178

As stated at the beginning of this chapter, there were six research questions. The first question was to investigate the relationship between preference and evaluation of sustainability. Bivariate correlation (Pearson's product-moment correlation) was used to answer this question. Partial correlations were also employed to make sure that the correlation between preference and cognitive evaluation was not mediated by a third variable.

The second question was the classification of the eleven design examples and generation of categories. The statistical method engaged for this purpose was hierarchical cluster analysis. This particular analysis enables researchers to classify cases into several homogeneous groups (Aldenderfer & Blashfield, 1984). Clusters in this study were generated based on participants' preference and evaluation of sustainability. In other words, the analysis aimed to identify shared characteristics that elicit a similar degree of preference and evaluation. These two variables were selected because the possible similarity of design examples in terms of preference and cognitive evaluation was of interest in the study.

The third question of the research was to identify salient dimensions in participants' perception of sustainable design. To address this question, principal factor analysis was applied to the ten semantic differential items to produce "factors" that may be considered to be underlying characteristics involved in the perception of sustainable design. Salient perceptual characteristics were construed by seeking a common attribute among the items belonging to the same factor.

The fourth research question was to test two hypotheses regarding the effects of different levels of information concerning sustainability on preference and evaluation of sustainability. The hypotheses (H_1 and H_2) are stated in the beginning part of this chapter. Analysis of variance (ANOVA) was employed for this purpose. The dependent variables (DVs) of the analysis were preference and cognitive evaluation. The independent variables (IVs) included the treatment (different levels of information concerning sustainability) and culture. Since multiple dependent variables are involved, differences of group means are normally explored by multivariate analysis of variance (MANOVA). MANOVA is appropriate when a researcher is interested in the multivariate aspect of data, i.e., experimental effects on multiple dependent variables taken as a set (Weinfurt, 1995). However, this study is interested not in the effects of the information on preference and cognitive evaluation as a "set" but in the separate effects of the information (and culture) on each of the dependent variables. For this reason, two-way univariate ANOVAs were applied separately to preference and evaluation of sustainability.

The fifth question of the research involved the construction and testing of hypothetical models to explain preferences for sustainable design. The models included evaluation of sustainability, environmental knowledge, and attitudes as predictors. Structural equation modeling (SEM) was used to test the hypothetical models. SEM is "a technique used for specifying and estimating models of linear relationships among variables" (MacCallum & Austin, 2000, p. 202). Figure 26 is one of the models to be tested. This model was constructed based on the four hypotheses (H_3 to H_6) stated earlier in this chapter. An alternative model will be shown later. SEM assesses the strengths of relationships between variables in a model, estimates the amount of variance of endogenous variables explained in the model, and provides several indices regarding the goodness of fit between the model and the data.

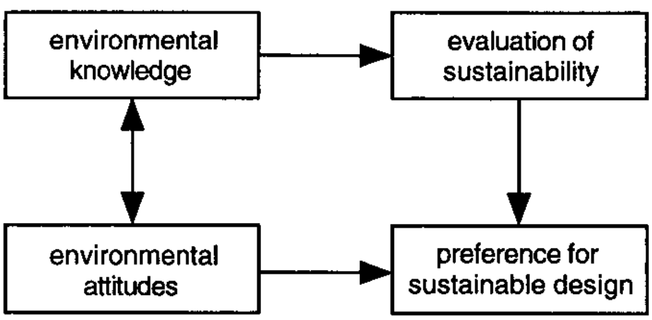


Figure 26. A hypothetical model of preference for sustainable design.

SEM allows researchers to investigate causal relationships between latent variables, which are not directly observable, but can be approximated by two or more measured (observed) variables (Hair, Anderson, Tatham, & Black, 1995). SEM typically has two stages in its analysis: (1) the specification of latent variables with a combination of measured variables, and (2) the construction and test of a *structural model* that includes causal relationship between latent variables. The hypothetical models in the present study include four latent variables: preference, evaluation of sustainability, environmental knowledge, and attitudes. Preference was measured with a single item (like–dislike) in the other analyses in this study. However, in SEM, preference was also considered as a latent variable, which is measured as a multiple item scale. To determine which observed variables are measuring each latent variable, factor analysis was employed in this study. This way of specifying latent variables was practiced in past studies (e.g., Kaiser & Shimoda, 1999; Kaiser et al., 1999). Upon specification of each latent variable, structural models were constructed and tested. To test the structural models, the statistical package AMOS was used (Arbuckle, 1997).

The sixth and last question concerned the cultural comparisons between the Japanese and Australian samples. Similarities and differences of the two culture groups were assessed by using correlation and ANOVAs. Correlation was used to examine the degree of agreement between the two groups of participants. ANOVAs were engaged to investigate cultural differences in preference and cognitive evaluation. Based on the two-way ANOVAs conducted in relation to the fourth question of the research (the effects of information on preference and evaluation), the main effect of culture and interactional effects of information and culture were assessed in this section. The hypothesis related to cultural comparisons of preference and cognitive evaluation (H_7) was examined based on the results of the two-way ANOVAs.

Chapter Six

RESULTS AND DISCUSSION

This chapter will report on and discuss the empirical results of the research. It is organised into six sections according to the six research questions. In each section, after a short description of the research question and associated hypotheses, the results of analyses followed by discussion will be presented.

Relationships between Preference and Evaluation of Sustainability

The first research question was to find out whether and to what extent people prefer sustainable design. To answer this question, the relationships between mean preference and evaluation of sustainability were examined through bivariate and partial correlation.

Descriptive statistics

Tables 11 and 12 indicate a number of valid responses (*n*), mean (*M*), standard deviation (*SD*), and rank order of mean (rank) of preference ratings and evaluation of sustainability across the participants for each design example. Preference rating ranged from 0 (*least preferred*) to 6 (*most preferred*). Likewise, evaluation of sustainability ranged from 0 (*least sustainable*) to 6 (*most sustainable*). Preference rating is a response to the like–dislike item in the semantic differential scale. Evaluation score is a mean of the six items of the Perceptual Sustainability Evaluation scale. As described earlier in Chapter 5, the photographs of the pond, solar house, and commercial complex had a smaller number of responses because they were not evaluated at one university due to time constraints.

The most preferred image in the examples was the windmill followed by the drainage, suburban house, park, pond, and wetland. The least preferred image was the apartment followed by the research centre and commercial complex. The examples perceived to be highly sus-

Table 11

Preference Ratings of the Design Examples

No	Design example	*n*	*M*	*SD*	rank
1	Windmill	235	4.472	1.269	1
2	Wetland	235	3.804	1.478	6
3	Pond	177	3.836	1.431	5
4	Solar House	178	3.596	1.524	7
5	Drainage	234	3.880	1.378	2
6	Sod covered house	234	3.342	1.611	8
7	Commerical complex	178	2.972	1.738	9
8	Research centre	234	2.863	1.547	10
9	Apartment	234	2.624	1.472	11
10	Suburban house	234	3.876	1.487	3
11	Park	235	3.843	1.490	4

Table 12

Evaluation of Sustainability of the Design Examples

No	Design example	*n*	*M*	*SD*	rank
1	Windmill	234	4.798	0.791	1
2	Wetland	234	4.320	0.844	3
3	Pond	177	4.471	0.851	2
4	Solar House	177	3.868	1.173	5
5	Drainage	234	4.108	0.973	4
6	Sod covered house	234	3.834	0.988	6
7	Commerical complex	177	2.400	1.252	8
8	Research centre	235	2.184	1.300	9
9	Apartment	234	2.017	1.112	10
10	Suburban house	235	1.944	0.984	11
11	Park	234	2.767	1.295	7

tainable include the windmill, pond, wetland, and drainage. The suburban house, apartment, research centre, and commercial complex were considered to be the least sustainable among the examples.

It is interesting to notice that the mean score and standard deviation are negatively correlated both in preference ratings and evaluation of sustainability. The Pearson's product-moment correlation coefficients between means and standard deviations were – .682 ($p < .05$) in the case of preference and – .715 ($p < .05$) in the case of evaluation of sustainability. This signifies that more agreement (less variability) in preference and evaluation among the participants exists for highly preferred and highly evaluated design examples. The relationships indicated here are consistent with the findings of other studies such as Dearden (1981) and Hagerhall (2001).

Bivariate correlations

In order to answer the first question of the research, the bivariate correlation between preference and evaluation of sustainability was examined. Figure 27 illustrates a scatter plot showing preference ratings and evaluation scores of the 12 design examples. The mean scores of preference and evaluation in Tables 12 and 13 were graphically represented in this graph. Each dot in this figure indicates a mean preference rating and evaluation score across all the participants of one design example. Black dots signify sustainable design examples, whereas white dots refer to unsustainable design examples. The scatter plot shows a strong correlation between mean preference and evaluation of sustainability in the sustainable design examples. The Pearson's correlation coefficient in this case was .953 ($p < .001$). A significant correlation coefficient of .679 ($p < .05$) was obtained when the two unsustainable design examples were included in the calculation.

Since 57 participants at Kyushu University evaluated only eight design examples, the number of participants rating the design examples varied considerably. It may be claimed that the

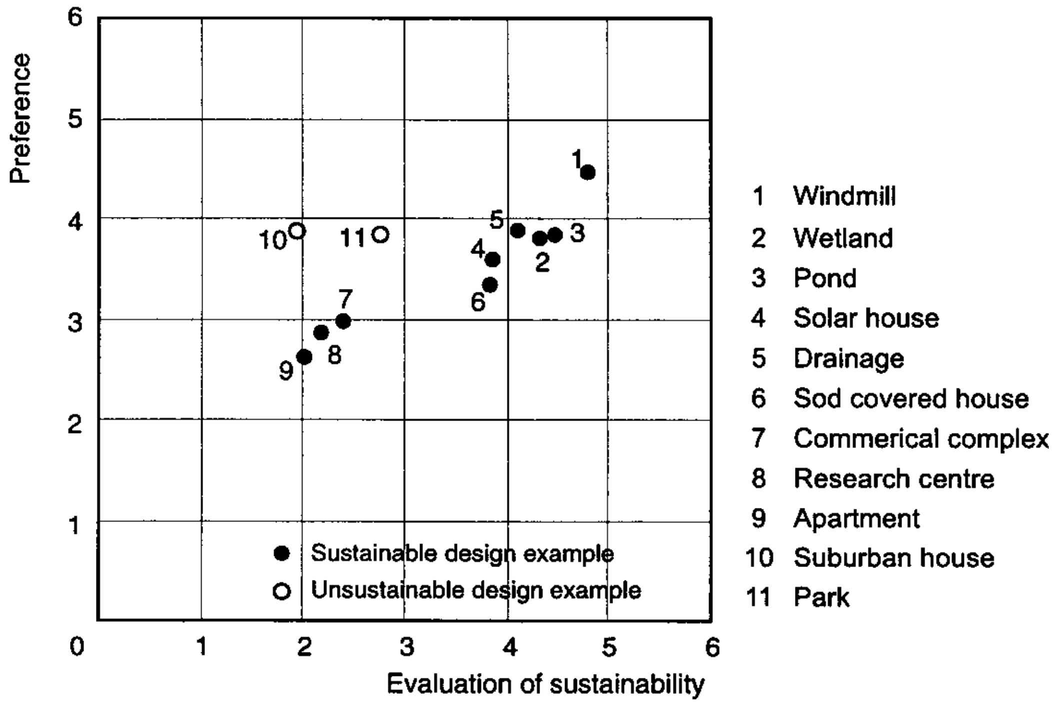


Figure 27. Scatter plot of mean preference and evaluation of sustainability of the design examples.

basis of comparison was not the same across the examples in the above analysis. Thus the same analysis was conducted without these 57 participants (Data Set A). Similar to the original analysis, significant correlations were obtained. The correlation coefficients between mean preference and cognitive evaluation in this case were .933 ($p < .001$) in the sustainable design examples and .675 ($p < .05$) in all the design examples.

The bivariate correlation between preference and evaluation of sustainability based on individual participants also indicated highly significant correlation. Figure 28 illustrates the scatter plot of a mean preference and evaluation of sustainability across the nine sustainable design examples. In this graph, each dot represents one participant. The correlation coefficient of 178 participants was .487 ($p < .001$). As far as mean preference and evaluation scores of two unsustainable design examples were concerned, a lower but still significant correlation of .245 ($p < .01$) was obtained.

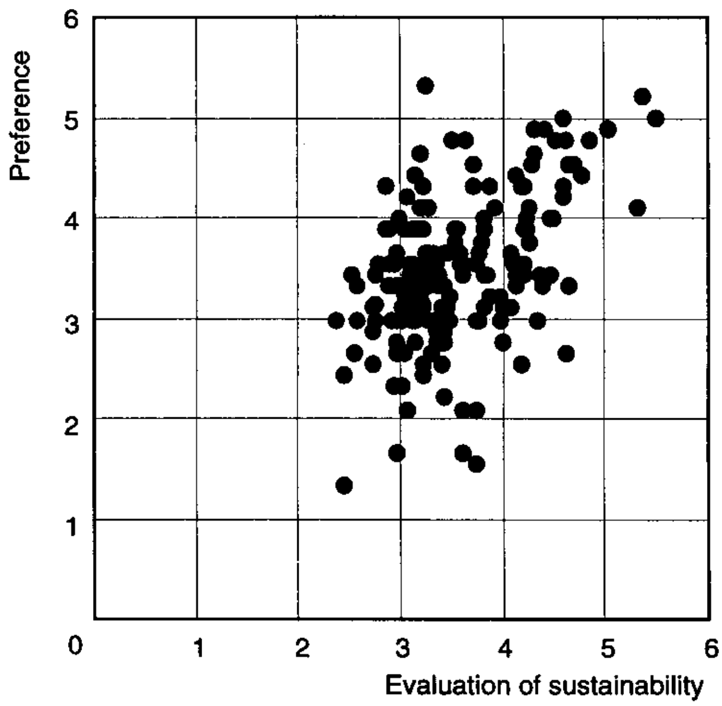


Figure 28. Scatter plot of mean preference and evaluation of sustainability across the nine sustainable design examples (n = 178).

Partial correlations

Looking at what were preferred and considered sustainable (the windmill, drainage, wetland, and pond), and what were not preferred and considered less sustainable (the apartment, research centre, and commercial complex), it may be thought that the correlation between preference and evaluation of sustainability is spurious. Past studies have shown that people prefer environments that look natural over environments that are built (e.g., Hodgson & Thayer, 1980; R. Kaplan, 1983; Purcell, Lamb, Peron, & Falchero, 1994). Thus, it is possible to suspect that a strong correlation between preference and cognitive evaluation is a result of mediation by perception of naturalness. Indeed, as Table 13 demonstrates, strong and significant correlations do exist between evaluation of sustainability and naturalness. This implies that people tend to think that design examples perceived to be natural contribute to environmental sustainability. Moderate correlation coefficients were also found between preference

Table 13

Bivariate (Zero Order) Correlation Coefficients between Preference, Evaluation of Sustainability, and Naturalness

	Preference	Evaluation	Naturalness
Preference	1.	.953***	.659
Evaluation	.679*	1.	.815**
Naturalness	.584	.784**	1.

Note. The upper right half shows correlation coefficients of sustainable design examples ($n = 9$). The lower left half indicates correlation coefficients of all the examples ($n = 11$). The analysis is based on mean scores across the participants.

*$p < .05$. **$p < .01$. ***$p < .001$.

and naturalness, however they were not significant.

To test whether the relationship is spurious, the partial correlation coefficient between preference and evaluation controlling for naturalness was calculated for the sustainable design examples. The partial correlation coefficient was .955 ($p < .001$), which is almost identical to the original bivariate correlation. The analysis revealed that a highly significant and strong correlation between preference and cognitive evaluation exists even after the effect of naturalness is statistically removed.

Involvement of naturalness in this tripartite relationship was further examined by calculating variance of preference uniquely explained by cognitive evaluation or naturalness. Unique variance accounted for by cognitive evaluation is a square of the "part" correlation coefficient between preference (P) and evaluation of sustainability (E) controlling for naturalness (N), which is calculated in the next formula (Hair et al., 1995):

$$\text{Unique variance explained by evaluation} = \frac{(r_{PE} - r_{PN}\, r_{EN})^2}{(1 - r_{EN}^2)}.$$

In this equation, r_{PE} is a bivariate correlation coefficient between P (preference) and E (evaluation of sustainability). Inserting the figures in the upper right half of Table 13 into this formula, it was obtained that the unique variance of preference explained by evaluation of sustainability was .516. The same equation calculated that the unique variance explained by naturalness was .041. This means that cognitive evaluation accounted for over 50 percent of the total variance of preference, while the perception of naturalness explained only four percent of the variance. As this demonstrates, naturalness has marginal relevance in preference for sustainable design compared to evaluation of sustainability.

Discussion about the relationships between preference and evaluation

As far as the presented design examples were concerned, the analyses strongly suggest that undergraduate students in Japan and Australia prefer images they consider sustainable. However, at the same time, the unsustainable design examples (the suburban house and park) were also highly preferred despite that they were judged less sustainable. The mixed results imply that people's evaluation of sustainability is associated with their preferences for sustainable design, but the relationship is not likely to apply to preferences for culturally favoured images. As Nassauer (1995a) pointed out, cultural conventions have very strong influences on the way people perceive the environment. In other words, satisfaction of the cultural demands is a more important criterion than evaluation of sustainability in making preference judgments. The lower correlation coefficient between preference and evaluation in the unsustainable (and culturally favoured) design examples also seems to support the relatively minor importance of evaluation of sustainability in culturally favoured images. The role of the cultural dimension in preference will be discussed further via cluster analyses reported in the next section.

In the previous chapter, two conflicting views in relation to preference for sustainable design were presented. In one view, environments managed for sustainability are often less preferred compared to those managed for aesthetics. The other view holds that sustainable design is preferred because of its long range benefits to the environment and survival of people. Focusing on the very strong correlation between preference and evaluation of sustainability, the results seem to support the idea that people prefer sustainable design. However, the fact that preferences for the unsustainable design examples were higher than preferences for some of the sustainable design examples appears to be in accord with the former view. The two views may not be exclusive to each other. Sustainable design includes a broad range of designed environments. It is not surprising that some of them are less preferred than environments designed aesthetically to be preferred by people. The important finding here is that within the realm of the sustainable design examples, evaluation of sustainability is highly associated with preference.

The relationships between preference ratings and their standard deviations seem to provide some insights into the issue of affect and cognition in preference. As argued previously, affective responses to a stimulus are considered innate and have found to be relatively common across individuals. On the contrary, cognitive responses tend to vary depending on personal factors such as age, gender, education, and cultural background. Thus, it can be hypothesised that if preference is based on affect, it will have more agreement (less variance) among respondents. Conversely, preference relying on cognition is likely to have less agreement (more variance). Putting this hypothesis and the results of the analysis together, it is possible to speculate that affective responses are dominant in preferences for images such as the windmill, drainage, and pond. Similarly, preferences for images such as the apartment and research centre can be considered primarily based on cognitive processes. As far as the stimuli presented were concerned, it can be inferred that preferences for "natural" images tend to be affect-oriented, while those for "built" images are more dependent on cognition. This inference is consistent with empirical findings by Zube and Pitt (1981) who found that preferences for built structures tend to vary between different cultures. Similarly, Saito (1998) pointed out that in a "scenically challenged" environment such as the buildings used as stimuli in this present study, cognition plays a more positive role.

The way perception of naturalness is engaged in preference and evaluation of sustainability appears complex. Although naturalness was highly correlated with evaluation of sustainability ($r = .815, p < .01$), the partial correlation analysis indicated that perception of naturalness has a limited effect on preferences for sustainable design. Many past preference studies have demonstrated a strong link between preference and naturalness (e.g., Herzog, 1989; R. Kaplan, 1983, Purcell et al., 1994; Sheets & Manzer, 1991). It has been suggested that natural elements such as vegetation and a body of water are preferred not only because of their cultural values but also because of their biological importance (e.g., Bourassa, 1990; S. Kaplan, 1987). Some studies have suggested that "tranquility" inherent in natural scenes is related with people's preference judgement (e.g., Herzog & Barnes, 1999; Herzog & Bosley, 1992). In the same line of exploration, several other studies have pointed out the important role of the "restorative quality" of natural environments (e.g., Hartig et al., 1991; S. Kaplan, 1995; Purcell et al., 1994). However, analysis discussed later in this study suggested that naturalness is associated rather with perception of "untidiness." This may explain the weak relationship between preference and naturalness in the present research. A detailed discussion on the issue of naturalness is found later in the section of salient perceptual characteristics of sustainable design.

Classification of the Design Examples

The second question of the research pertained to the classification of the design examples in order to understand underlying dimensions involved in perceptual grouping of the examples. Cluster analysis was employed for this purpose.

Cluster analysis

The eleven design examples were classified into groups by using hierarchical cluster analysis. Since all the design examples needed to be included, Data Set A (n = 178) was used for the analysis. Cluster analysis develops groups of cases according to "similarity" between the cases (Hair et al., 1995). To measure similarities between the design examples in this study, the preference rating and evaluation score of each example were used. This means that there were two series of scores for each design example to be classified. To apply cluster analysis to this data, Data Set A was arranged to have the design examples as variables and participant's preference and evaluation scores as cases. The number of data in this analysis was 3872 (11 variables x 352 cases).[4] An alternative analysis in which mean scores of preference and evaluation across 178 participants were used was also conducted to test the results of the first analysis. The number of data in this alternative analysis was 22 (2 variables x 11 cases). Ward's method with squared Euclidian distance was applied to form clusters in both analyses. This clustering algorithm was chosen because it can develop clusters with a small number of observations (Hair et al., 1995). Data were not standardised since both variables had the same 7-point scale.

Figure 29 is a dendrogram showing the results of the hierarchical cluster analysis. The dendrogram graphically illustrates which items are formed into a cluster at what distance. The length of horizontal lines connected by a vertical line indicates distance (a degree of similarity) between the items or clusters. Shorter horizontal lines signify shorter distance between design examples, hence the more similarity between them. Figure 29 suggests a three-cluster solution. Figure 30, which shows the clusters in the scatter plot of mean preference and evaluation, appears to indicate that the three-cluster solution is consistent with the grouping observable in the scatter plot. The alternative analysis also developed the same cluster membership, although there were slight differences in distances within the dendrograms.

Cluster 1 includes the wetland, pond, drainage, solar house, sod covered house, and windmill. These images are highly preferred and score high in evaluation of sustainability. Cluster 2 consists of the research centre, apartment, and commercial complex. The design examples in this cluster are not so preferred and have low evaluation scores. Cluster 3 contains

4. Missing data ($n = 4$) were deleted casewise.

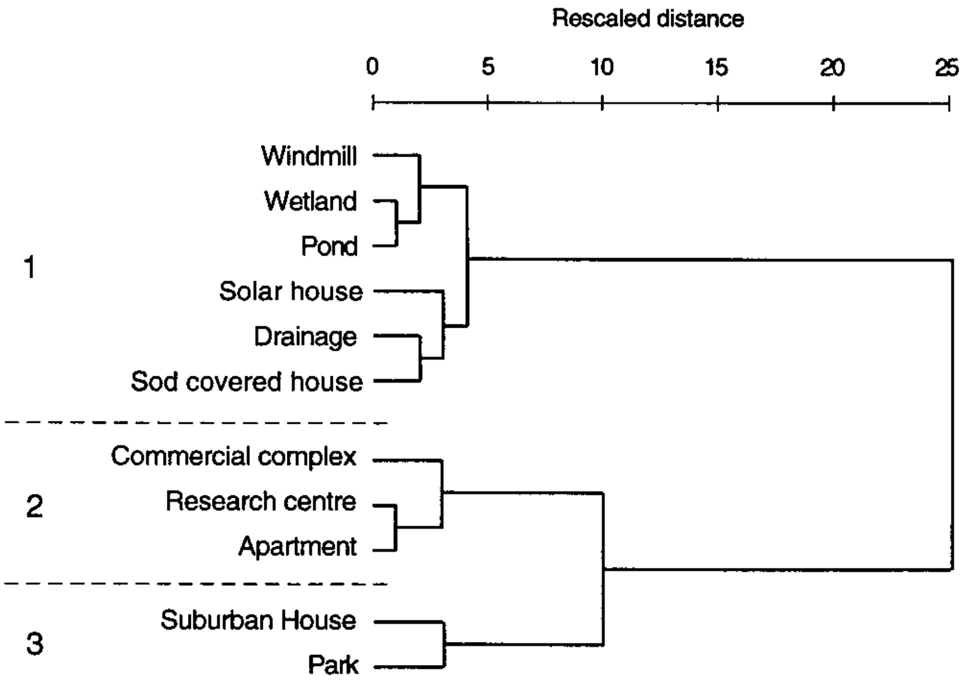


Figure 29. Dendrgram showing the result of hierarchical cluster analysis.

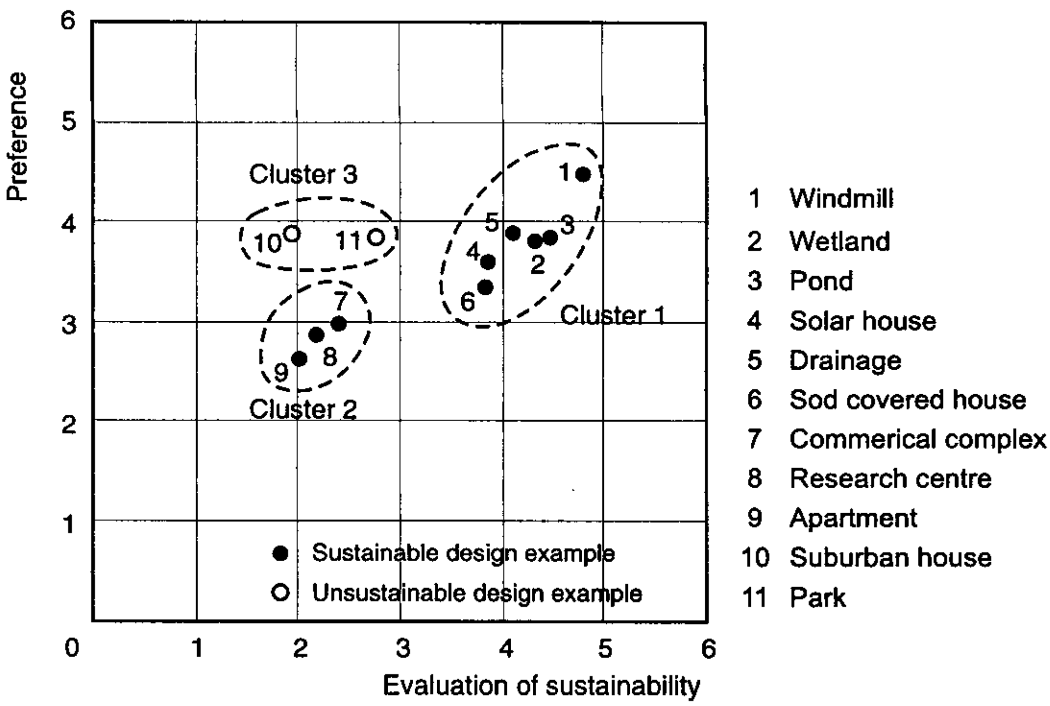


Figure 30. Three clusters shown in the scatter plot of mean preference and evaluation of sustainability.

the two unsustainable examples: the suburban house and park. The images in this cluster are also preferred, but their evaluation scores are relatively low.

Cluster 1 is classified to include high preference and high evaluation design examples. Cluster 2 contains low preference and low evaluation design examples. Cluster 3 includes high preference and low evaluation design examples. It needs to be added that the examples in Cluster 3 are designed considering mainly aesthetics but not sustainability. Table 14, which shows group means of preference and evaluation of sustainability of the three clusters, validates this interpretation. As the table demonstrates, statistically significant differences were found between the clusters in terms of preference and evaluation.

Table 14

Comparisons of Group Means of Preference and Evaluation in the Three-Cluster Solution

	Cluster 1	Cluster 2	Cluster 3	*F* ratio	significance
Preference	3.775	2.869	3.831	8.87	$p < .01$
Evaluation	4.253	2.235	2.423	30.39	$p < .001$

To test the stability of the cluster solution, hierarchical cluster analysis with the same method was conducted for two halves of the sample separately (Aldenderfer & Blashfield, 1984). For this purpose, Data Set A was randomly split into two halves, then preference and evaluation scores were arranged again in each of them. It turned out that the results from the two subsamples were quite similar not only to each other but also to the result acquired from the entire Data Set A. The results from the alternative analyses support the initial findings.

Discussion about classification of the design examples

Implied in the above results are underlying criteria that differentiate the clusters. What distinguishes Cluster 1 and 2 appears to be easiness for the participants to detect the photographed example's contribution to sustainability. It seems evident that the images in Cluster 1 such as the windmill and pond are contributing to or at least not disturbing the sustainability of the environment. It is probably the reason these images scored high in evaluation of sustainability. On the other hand, the three images in Cluster 2 present few clues as to their involvement in efforts to promote sustainability. In reality, these buildings incorporate technologies, materials, and overall design to help improve sustainability of the environment. However, due to the absence of any visual cues that suggest their contribution to sustainability, these examples in Cluster 2 were perceived negatively in terms of sustainability. In addition to the images, the titles attached to the photographs may have had some impacts on participants' evaluation of sustainability. Terms such as "windmill" are almost always associated with efforts to reduce environmental impact and achieve healthy environment, whereas "commercial complex" and "research centre" normally have little to do with the idea of sustainability.

It appears that the two images in Cluster 3 are differentiated from the rest because of their conformity to cultural values. The suburban house and park, unlike the images in Cluster 1 and 2, are closely associated with ideas such as high social status, good life, and leisure, which are highly regarded both in Japanese and Australian societies. As discussed before, these images were highly preferred regardless of their low evaluation in terms of sustainability. The analysis implies the preeminence of cultural demands in perception of sustainable design. It has to be noted that theses images were considered to have a distinct difference from the other stimuli and were inserted for the purpose of comparison with the sustainable design examples. It can be claimed that the cluster analysis substantiated this difference.

Based on the above discussion, it is possible to infer two latent dimensions involved in the classification of the stimuli. The first dimension, which distinguishes Cluster 1 and 2, can be interpreted as *visibility of sustainability*. The second dimension separating Cluster 3 from the rest can be regarded as *conformity to cultural values*. Using these interpretations, Cluster 1, 2, and 3 will be referred as "sustainable/visible," "sustainable/invisible," and "unsustainable" in the following sections of the thesis.

It has to be stressed that the existence of the two latent dimensions was not empirically verified. However, substantial discussion on these issues is found in the literature concerning the social aspect of environmental sustainability. For instance, the difficulty of visually recognising sustainability of built environments has been criticised as an obstacle for efforts to attract public support for sustainable design (Mozingo, 1997). Active human engagement is unlikely to happen in an environment which people do not understand what it is. In the area of ecological sustainable design that tends to be difficult to recognise for lay public, Thayer (1989) proposed "conspicuous design" in which the appearance of sustainable design asserts its existence and communicates its functions. Similarly, Gobster (1994) stressed the importance of visibly identifiable ecological functions to bridge people and ecological sustainable design.

With respect to the cultural demands, Rapoport (1994) pointed out that the current vocabulary of sustainable design is at odds with our cultural expectations. He and other researchers argue that sustainable design which disregards cultural demands of a society will not be widely adapted. For instance, Nassauer (1997b) commented that "ecological solutions have been realized to the extent that they fit culture" (p. 4). Thus, approaches toward a sustainable society have to embrace the current values of our culture so that they can be integrated into the everyday life of people. Acknowledging both the issues of visibility and cultural values, Eaton (1990) proposed to extend a culturally recognisable vocabulary to make sustainable design perceptible and compatible with the sociocultural wants of people. As the literature cited here suggests, the two latent dimensions inferred from the cluster analysis appear to play a substantial role in people's perception of sustainable design.

In the previous section, the thesis pointed out that evaluation of sustainability is highly associated with preference. The findings of this section indicate that the visibility of sustainability is another salient factor in preferences for sustainable design. The visibility separates the sustainable design examples into a group of preferred (Cluster 1) and unpreferred examples (Cluster 2). Figure 30 suggests that this factor could make sustainable design as preferable as "environments managed for aesthetics." The fact that the windmill, which contributes to environmental sustainability explicitly and visibly, is the most preferred image seems to support this inference. In addition, the solar house, which is a building equipped with visible sustainable features, also belongs to Cluster 1. This implies that adding visible cues which suggest sustainability to the buildings in Cluster 2 may increase preference for them.

The visibility of sustainability is a perceived quality of the environment. It is not a simple environmental attribute, but is also based on aspects of people who perceive the environment. Thus, to enhance the visibility of sustainability, manipulation of physical environments is not the only solution. The visibility may be altered by changing the way people see the environment. Telling people how a particular environment works to improve sustainability seems equivalent to increase the visibility. The effect of this type of information will be examined later in the present study.

It has been suggested from the results of this thesis that visibility of sustainability is an important factor for people to evaluate sustainable design. People's preference for and evaluation of sustainable design appears to be subject to this dimension to a considerable degree. Many studies have pointed out the lack of visibility as a serious issue for sustainable design. This part of the present study corroborates these arguments in the research literature.

Salient Perceptual Characteristics of the Sustainable Design Examples

The third question of the research was the identification of salient characteristics in perception of sustainable design. Applying factor analysis to participants' responses to the ten semantic differential items, the study aimed to understand major perceptual dimensions and how they are related to each other. Since the study is interested in sustainable design, participants' responses to the nine sustainable design were analysed.

Factor analysis

Principal factor analysis was carried out on the ten semantic differential items to identify salient perceptual characteristics of sustainable design. To have a wider range of design examples, Data Set A (n = 178) was used for the analysis. The data set includes nine sustainable design examples, each of which has responses to ten semantic differential items from 178 participants. To apply factor analysis to this data set, the raw data were arranged to have ten semantic differential items as variables and 9 blocks of 178 participants as cases. This way of data arrangement was chosen (instead of taking mean scores across participants or stimuli), because variability of the data may be lost by taking mean scores. The same way of data preparation can be seen in Hagerhall (2000). The number of cases in the data set was 1569.[5]

A measure of sampling adequacy (MSA) was checked to assess appropriateness of the data set for factor analysis. The MSA in this case was .794. According to Hair et al. (1995), MSA greater than .60 is considered acceptable for factor analysis. Thus, it was implied that the application of factor analysis to the data set was appropriate.

In factor analysis, the number of factors needs to be determined first. Criteria employed in deciding the number of factors were: (1) scree plot (point at which the line begins to straighten), (2) the cumulative percentage of the variance explained by factors (greater than 60 percent), and (3) eigenvalue (greater than 1.0) (Hair et al., 1995). Figure 31 depicts the scree plot. There was no clear indication of the number of factor from the scree plot. However, both the cumulative percentage of the variance and the eigenvalue suggested a three-factor solution. Thus three factors were extracted in the analysis.

5. Missing data (n = 33) were deleted casewise.

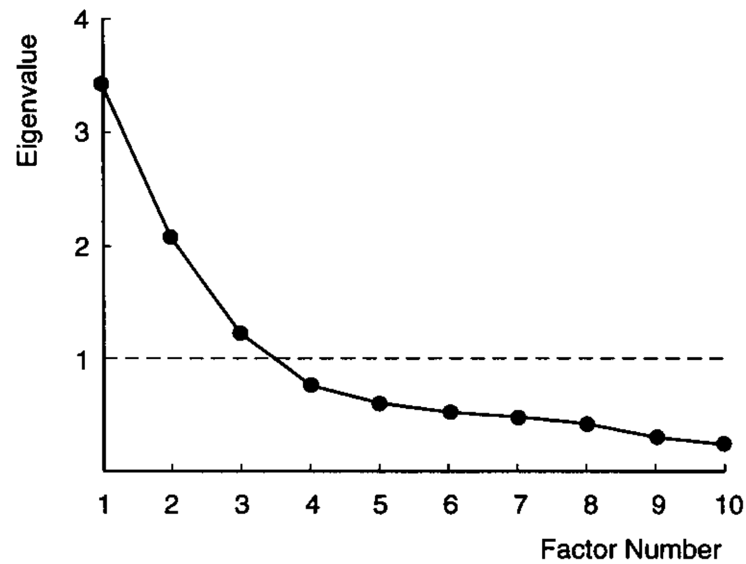


Figure 31. Scree plot of factor analysis applied to the semantic differential scale (n = 178).

Principal axis factoring method with oblique rotation (direct oblimin) was employed to obtain the factor matrix. The oblique rotation was applied to identify the correlation between factors. Factor loadings reported in this section are from the pattern matrix. Although factor loadings in excess of .3 can be considered practically significant for this sample size (Hair et al., 1995), to have clearer interpretation of factors, loadings in excess of .4 were considered to be constituents of a factor. Tables 15 and 16 show the factor matrix and factor correlation matrix respectively.

Factor 1 includes liking, attractiveness, beauty, and interestingness. This factor can be interpreted as *preference.*[6] The second factor includes simpleness (negative), naturalness (negative), and conspicuousness. If these items are interpreted in a reverse way, the factor contains something simple, natural, but unnoticeable. It is thus possible to characterise this factor as *plainness*. Factor 3 consists of unclutteredness, maintenance, and efficiency. The factor

6. Preference as a name of a factor is written in italics in this section to distinguish it from preference as a concept. The other factor names (plainness and tidiness) are also written in italics.

Table 15

Factor Matrix of the Semantic Differential Scale (n = 178)

	Factor 1 *Preference*	Factor 2 *Plainness*	Factor 3 *Tidiness*	Communalities
Like–Dislike	**.863**[a]	– .097	.085	.819
Attractive–Unattractive	**.781**	– .058	.093	.677
Beautiful–Ugly	**.727**	– .145	.122	.633
Interesting–Boring	**.706**	.209	– .053	.504
Simple–Complex	– .057	**– .692**	.282	.514
Natural–Human made	.328	**– .671**	– .259	.616
Conspicuous–Inconspicuous	.050	**.587**	.074	.360
Uncluttered–Cluttered	.048	– .179	**.634**	.439
Well maintained–Not well maintained	.113	.353	**.509**	.463
Efficient–Inefficient	.158	.083	**.425**	.264
% of variance	33.92	20.89	12.24	–

[a] Loadings in excess of .4 are shown in bold.

Table 16

Factor Correlation Matrix

	Factor 1	Factor 2	Factor 3
Factor 1	1.	–	–
Factor 2	– .047	1.	–
Factor 3	.348	.085	1.

involves neatness, good human care, and resulting good performance of designed environments. Thus, this factor can be interpreted as *tidiness.*

Discussion about salient perceptual characteristics

As Table 15 indicates, *preference* is the most dominant dimension in the perception of sustainable design. This factor appears to be mainly an affective reaction to the design examples. The adjectives such as beautiful and interesting were listed as descriptors of affective qualities of environments by Russell et al. (1981). *Plainness* seems concerned with the formal quality of the photographs. It contains complexity and conspicuousness, which are related to "forms" rather than "contents" of images. However, naturalness, which is not directly related to the formal quality, is also loaded on this factor. It may be because images considered natural happened to have the same formal qualities in terms of simpleness and inconspicuousness. *Tidiness* is likely to involve a cognitive response to the sustainable design examples. The factor includes unclutteredness, maintenance, and efficiency. It can be argued that one needs to collect and process information from images to make judgment on items such as a degree of maintenance and efficiency.

The relationships between the factors are of interest in this analysis. Table 16 displays that *preference* and *plainness* are fairly independent from each other ($r = -.047$), but *preference* and *tidiness* are moderately correlated ($r = .348$). The results suggest that (1) the formal quality of the stimuli such as simpleness and conspicuousness is a major dimension in the perception of sustainable design, but has little to do with preference, and (2) a cognitive response to sustainable design in terms of tidiness and care is somewhat associated with preference. This interpretation seems to support the argument regarding the minor importance of the formal quality of images in preference for sustainable design discussed in the previous chapter. It also supports the argument propounding the involvement of cognition in preferences for sustainable design.

That the factor of *preference* and that of *tidiness* are related in people's perception of sustainable design is consistent with the findings of the study by Nassauer (1993). Comparing residents' perceptions of conventional lawns and various patterns of native plant gardens, Nassauer found that the perception of care and neatness are highly associated with attractiveness in conventional and some ecologically improved landscapes. The results of factor analysis in the present study identified the same two factors. However, the correlation between the factors is not very strong in the present study. This difference between her study and this study may have stemmed from different types of stimuli used to elicit responses. Nassauer's research employed images of gardens only, while the study reported here used a wide range of stimuli including new and clean buildings that look far tidier than natural scenes. Despite the differences, the two studies concur that tidiness and care are important criteria people apply in perception of sustainable design.

The idea of care and resulting tidiness seem to play an important role in enhancing sustainability in the environment. An environmental movement has been shifting from preservation to restoration (Turner, 1994). It has been proposed that active human engagement and maintenance are essential in order to advance sustainability (Dubos, 1980). The idea of "sustainable communities," which began to emerge in the 1990s, also relies on careful management of the environment by local communities (Mazmanian & Kraft, 1999). According to Nassauer (1997a), the idea of care can bridge the gap between human perception and sustainability. Environments that exhibit care are more likely to be preferred and accepted by the public, and more likely to attract further attention and care (Nassauer, 1997a). The present factor analysis also suggests the importance of perception of care and tidiness in achieving sustainability in the environment.

It seems fair to say that naturalness has a complex role in the perception of sustainable design. Past preference studies have exhibited that naturalness is highly associated with preference (e.g., R. Kaplan & S. Kaplan, 1989). In fact, a factor loading of naturalness on Factor 1 is over .30 (Table 15). However, on the other hand, the correlation between *preference* and *plainness* which includes naturalness is very small. This indicates that perception of naturalness has little relevance to preference. This dilemma may be resolved by considering a different aspect of naturalness. The factor matrix shows that naturalness is also slightly associated with *tidiness*, although its loading factor is fairly small (.26). Natural images included in the stimuli (the pond, wetland, drainage, and sod covered house) may have given the impression of "untidiness" to the participants. The study of native plant gardens by

Nassauer (1993) discussed above also reported that perception of naturalness and that of lack of maintenance are highly correlated.

To check this observation, bivariate correlation coefficients between preference, naturalness, and unclutteredness were calculated and are shown in Table 17. In the case of Cluster 1 which includes images considered natural, a significant negative correlation was found between naturalness and unclutteredness ($r = -.222$). However, the similar degree of positive correlation was also found between preference and naturalness ($r = .243$), and between preference and unclutteredness ($r = .231$). Even though these coefficients are not very large, the analysis implies that the perception of naturalness has mixed contributions to preference: a positive contribution possibly from natural elements (tree, foliage, and water) and their restorative quality, and negative contribution from its rather untidy appearance. Correlation coefficients in the case of Cluster 2 form an interesting contrast. In this cluster, which includes three buildings, no significant negative correlation was observed between naturalness and unclutteredness. This suggests that the perception of naturalness in the case of the buildings does not have the same complex relationship with preference and tidiness. The results suggest that naturalness has equivocal characteristics in perception of some sustainable design examples.

Table 17

Bivariate Correlation Coefficients between Mean Preference, Naturalness, and Unclutterdness of Cluster 1 and Cluster 2

	Like	Natural	Uncluttered
Like-Dislike	1.	.243**	.231**
Natural-Built	.182*	1.	–.222**
Uncluttered-Cluttered	.188*	.071	1.

Note. The upper right half shows correlation coefficients in the case of Cluster 1. The lower left half indicates correlation coefficients in the case of Cluster 2 (n = 178).

*$p < .05$. **$p < .01$.

In summary, the factor analysis strongly suggests that, within the range of the semantic differential items assessed in the present study, *preference* is the most salient characteristics in the perception of sustainable design. The factor containing the formal quality, *plainness*, also appeared as an underlying perceptual dimension. However, the analysis found that *plainness* is not associated with *preference*. The factor of *tidiness*, which also includes perceptions of care and efficiency, also emerged as a salient factor. It was found that *preference* and *tidiness* are correlated to some degree.

Earlier in this chapter, the partial correlation analysis found that perception of naturalness has a limited role in preference. The results in this section suggest a complex role of naturalness in preference for sustainable design. Past studies on environmental preference have reported repeatedly that natural environments are preferred over built environments. However, the current research suggests that the relationship between naturalness and preference is not straightforward as far as the stimuli presented in this study are concerned. The factor analysis implied that the relationship between naturalness and preference is mediated by perception of tidiness and care. The relationships between preference, naturalness, and tidiness need to be investigated further in order to have a richer understanding of the perception of sustainable design.

Findings in this section include the importance of perception of tidiness and care in sustainable design. The environments that do not exhibit this characteristic are likely to be considered abandoned and unkempt. The importance of this factor is magnified when we consider the cultural dimension of sustainability. The cluster analysis identified that conformity to our cultural values is an important criterion in perception of sustainable design. Rapoport (1994) commented that the vocabulary of sustainable design is at odds with cultural values. However, as Nassauer (1997a) described, many culturally favoured environments exhibit tidiness and care. Thus, this dimension can be an effective way to improve the sociocultural aspect of sustainable design. It is important to inform environmental designers and managers of the importance of tidiness and care in sustainable design through further empirical research and dissemination.

Effects of Information about Sustainability on Preference and Evaluation

The fourth research questions concerned the effects of information related to sustainability on preferences for and cognitive evaluation of sustainable design. The following two hypotheses were examined in this question:

H_1: Those who received information about sustainability are likely to evaluate sustainable design more positively than those who did not receive information.

H_2: Those who received information about sustainability are likely to prefer sustainable design more than those who did not receive information.

Analysis of variance

The effects of information supplied to randomly assigned groups of participants were assessed through a univariate analysis of variance (ANOVA). There were two dependent variables in this analysis: preference and evaluation of sustainability. The reason multivariate analysis of variance (MANOVA) was not used for the analysis was explained in Chapter 5. In addition to the treatments of different levels of information, participants' culture (Japan or Australia) was also included as an independent variable in the analysis. Although this section presents the entire results of the two-way ANOVAs, it discusses only the main effect of different levels of information. The main effect of culture and the interactional effects between information and culture will be discussed separately in the section of cultural comparisons later in this chapter.

Since the analysis was interested in the effects of different levels of information on preference for and evaluation of sustainable design, ANOVAs were first applied separately to the sustainable design examples (9 stimuli) and unsustainable design examples (2 stimuli). They were analysed independently because information was expected to influence them in an inverse way. Combining sustainable and unsustainable design examples is likely to counteract the information effects. Then, in order to closely examine the effects of the information on different types of sustainable design, ANOVAs were also conducted for Cluster 1 and Cluster 2, which were derived empirically in the section of classification. As the previous section demonstrated, these clusters were considered different in terms of participants' preference and evaluation of sustainability. Thus, it was expected that the way the information influences preference and evaluation is different between the clusters.

ANOVA was performed eight times in the analysis, since separate analyses for preference and cognitive evaluation were necessary for each of the four conditions: sustainable design, unsustainable design, Cluster 1, and Cluster 2. One argument related to the use of multiple statistical tests is inflated Type I error risk (e.g., Hair et al., 1995; Huck, 2000). In order to hold down the chance of inflated Type I error, the Bonferroni adjustment procedure was applied to the level of significance (e.g., Huck, 2000). Considering the number of tests to be performed, the level of significance was raised from .05 to .01. The experiment-wise Type I error was .077 ($1 - 0.99^8$).

Four data sets were constructed from the raw data. Similar to the data arrangement made in the case of the factor analysis, blocks of 235 preference scores were aligned sequentially to form one variable.[7] For instance, in the data set for sustainable design examples, preference scores of the 9 stimuli were arranged to be treated as one variable. The same transformation was carried out for the evaluation scores. The number of cases in each condition was 1931 for the sustainable design examples (1287 in Cluster 1 and 644 in Cluster 2) and 468 for the unsustainable design examples.[8]

7. Since the pariticipants at Kyushu University ($n = 57$) did not evaluate three images, there were three blocks that had only 178 participants.

8. The number of missing data were 13 in sustainable design examples (9 in Cluster 1 and 4 in Cluster 2) and 2 in unsustainable design examples. They were deleted casewise.

Since ANOVA is highly sensitive to outliers, it is necessary to detect outliers and exclude them (Hair et al., 1995). The current analysis has three levels of information and two levels of culture. On each level, standardised scores of preference and evaluation were calculated. Z scores in excess of 3 were considered outliers and excluded casewise from the data sets according to the procedure recommended by Hair et al. (1995). The number of outliers was 9 in the sustainable design examples (7 in Cluster 1 and 2 in Cluster 2) and 3 in the unsustainable design examples. The final number of cases was 1922 in the sustainable design examples (1280 in Cluster 1 and 642 in Cluster 2) and 465 in the unsustainable design examples. Table 18 summarises the number of cases at each level in the four conditions.

Table 18

Number of Cases at Each Level of ANOVAs in the Four Conditions

	Level	Sustainable	Cluster 1	Cluster 2	Unsustainable
Information	CG	697	464	233	168
	TG1	712	474	238	170
	TG2	513	342	171	127
Culture	Japanese	974	649	325	254
	Australian	948	631	317	211
Total		1922	1280	642	465

The null hypotheses to be tested in the analysis were as follows: (1) there will be no difference in participants' preference and evaluation of sustainability according to the levels of information (CG, TG1, and TG2), (2) there will be no difference in participants' preference and evaluation of sustainability according to their cultural backgrounds (Japanese and Australian), (3) there will be no influence on participants' preference and evaluation of sustainability associated with the joint effects of the levels of information and their cultural backgrounds. These hypotheses were tested in four conditions. The second and third hypotheses will be discussed later in the section on cultural comparisons.

One of the assumptions of ANOVA is the equivalence of variance across groups, which can be assessed by Levene's test of equality of error variance (Hair et al., 1995). Out of eight ANOVAs, the equality can be assumed only in two cases (evaluation in sustainable design examples and preference in unsustainable design examples). However, a violation of this assumption has minimum impact when the number of cases on each level is roughly equal. The criterion is that the largest group size divided by the smallest size is less than 1.5 (Hair et al., 1995). Table 18 indicates that the largest difference in group size was found between TG1 and TG2. Since their ratios are smaller than 1.4, application of ANOVA to the data sets was judged adequate. However, to support the results of ANOVAs, nonparametric tests of group differences (Kruskall–Wallis test) were also conducted for the same data sets.

The results of ANOVAs for sustainable and unsustainable design examples are shown in Tables 19 and 20. A shaded area in the tables concerned cultural comparisons, and is discussed later in this chapter. Figures 32 to 35 are graphic representations of mean preference and evaluation scores for the respective cases. In these figures, a line chart instead of bar chart was chosen to indicate the information effects in order to clearly illustrate the interaction effects between information and culture in later analyses.

Table 19 indicates that the null hypotheses concerning the effects of information were rejected both in preference and evaluation of sustainability. Provision of information caused a significant difference between the groups in evaluation of and preference for sustainable design examples. However, the effect size in the case of preference is small ($\eta^2 = .013$) according to the criteria recommended by Cohen (1988). Although the analysis produced a significant effect thanks to a large sample size (n = 1922), the effect size indicates that the influence of information on preference has a limited practical significance (Huck, 2000). In the case of evaluation, information had a larger effect size ($\eta^2 = .084$), which is in the range of medium to large effect against the same criteria suggested by Cohen (1988).

Table 19

ANOVAs of Preference and Evaluation of Sustainability (Sustainable Design Examples)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)	Pref	64.98	2	32.49	13.02	.000***	.013	.986
	Eval	339.63	2	169.81	88.35	.000***	.084	1.000
Culture (C)[b]	Pref	0.66	1	0.66	0.27	.606	.000	.021
	Eval	0.78	1	0.78	0.41	.524	.000	.027
I x C[b]	Pref	12.25	2	6.13	2.45	.086	.003	.266
	Eval	0.72	2	0.36	0.19	.830	.000	.020
Error	Pref	4782.89	1916	2.50				
	Eval	3682.64	1916	1.92				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] Cultural and interactional effects of information by culture are discussed later.

$^{**}p < .01$. $^{***}p < .001$.

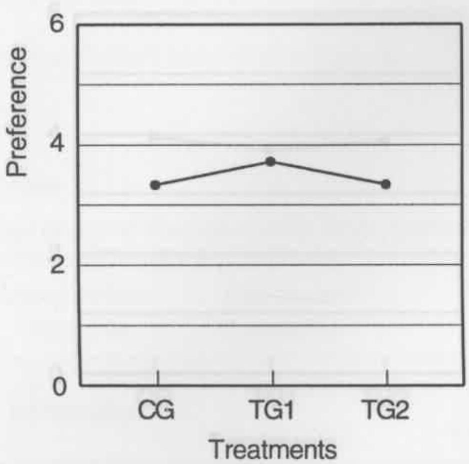


Figure 32. Group means of preference (Sustainable design examples).

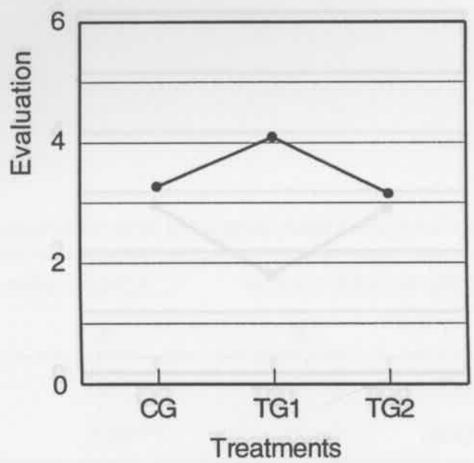


Figure 33. Group means of evaluation (Sustainable design examples).

Pair-wise post-hoc tests (Tukey's HSD) identified that specific information (TG1) had a significant impact on preference ($p < .001$) and on evaluation of sustainability ($p < .001$) in comparison to the control group (CG). The post-hoc tests also found that general information (TG2) had no effect on preference or evaluation of sustainability.

Table 20

ANOVAs of Preference and Evaluation of Sustainability (Unsustainable Design Examples)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)	Pref	3.42	2	1.71	0.79	.454	.003	.064
	Sus	135.99	2	68.00	59.50	.000***	.206	1.000
Culture (C)[b]	Pref	17.54	1	17.54	8.12	.005**	.017	.604
	Sus	3.17	1	3.17	2.78	.096	.006	.180
I x C[b]	Pref	2.84	2	1.42	0.66	.519	.003	.052
	Sus	0.72	2	0.36	0.31	.731	.001	.027
Error	Pref	991.64	459	2.16				
	Sus	524.56	459	1.14				

[a] "Pref" and "Sus" signify preference and evaluation of sustainability respectively.

[b] Cultural and interactional effects of information by culture are discussed later.

$^{**}p < .01$. $^{***}p < .001$.

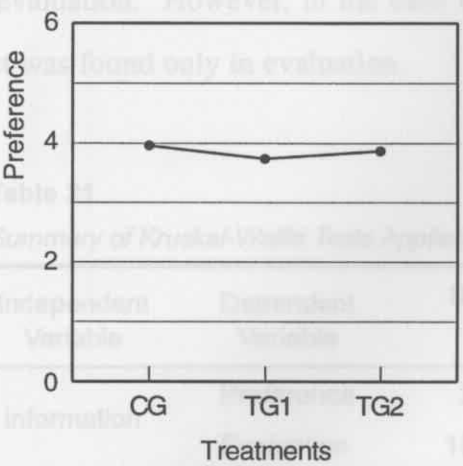


Figure 34. Group means of preference (Unsustainable design examples).

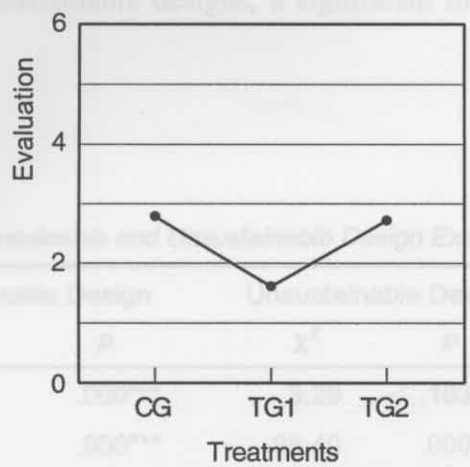


Figure 35. Group means of evaluation (Unsustainable design examples).

With regard to the unsustainable design examples (Table 20), the null hypothesis was rejected only in the case of the evaluation of sustainability. The analysis failed to reject the null hypothesis concerning preference. Namely, as Figures 34 and 35 imply, a significant information effect was found in the evaluation of sustainability but not in preference. In the case of evaluation of sustainability, a large effect size ($\eta^2 = .206$) due to information was obtained. The post-hoc tests found that a significant difference ($p < .001$) in evaluation exists between TG1 and the rest, i.e., specific information had a significant effect on evaluation of the unsustainable design examples.

In order to support the results of ANOVAs, nonparametric tests of group difference were applied to the same data sets. Table 21 shows the results of Kruskal-Wallis tests. Since the Kruskal-Wallis test is the nonparametric equivalent of one-way ANOVA, it had to be applied to each dependent variable (DV) with a single independent variable (IV). Group differences in preference and evaluation scores due to different levels of information were examined. The analyses produced similar results to the ANOVAs shown in Tables 19 and 20. In the case of sustainable designs, significant differences between the groups were found in preference and evaluation. However, in the case of unsustainable designs, a significant information effect was found only in evaluation.

Table 21

Summary of Kruskal-Wallis Tests Applied to Sustainable and Unsustainable Design Examples

Independent Variable	Dependent Variable	Sustainable Design		Unsustainable Design	
		χ^2	*p*	χ^2	*p*
Information	Preference	26.37	.000***	3.29	.193
	Evaluation	154.79	.000***	98.40	.000***

**p < .01. ***p < .001.

The results of ANOVAs for Cluster 1 and Cluster 2 are shown in Tables 22 and 23. Mean group preference and evaluation scores of each cluster are shown in Figures 36 to 39. In Cluster 1 (Table 22), the null hypotheses were rejected both with respect to preference and evaluation of sustainability. The analysis found that information had significant effects on both dependent variables. The effect sizes were rather small ($\eta^2 = .020$) in preference and in

Table 22

ANOVAs of Preference and Evaluation of Sustainability (Cluster 1: Sustainable/Visible)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)	Pref	55.27	2	27.63	12.85	.000***	.020	.984
	Eval	94.14	2	47.07	53.41	.000***	.077	1.000
Culture (C)[b]	Pref	3.06	1	3.06	1.42	.233	.001	.083
	Eval	0.38	1	0.38	0.43	.514	.000	.028
I x C[b]	Pref	16.79	2	8.40	3.91	.020	.006	.472
	Eval	1.46	2	0.73	0.83	.438	.001	.067
Error	Pref	2739.01	1274	2.15				
	Eval	1122.71	1274	0.88				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] Cultural and interactional effects of information by culture are discussed later.

$^{**}p < .01$. $^{***}p < .001$.

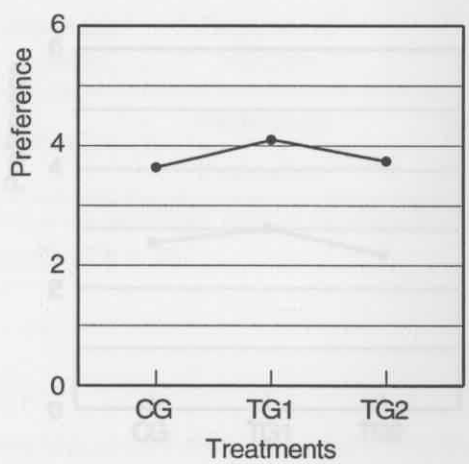


Figure 36. Group means of preference (Cluster 1).

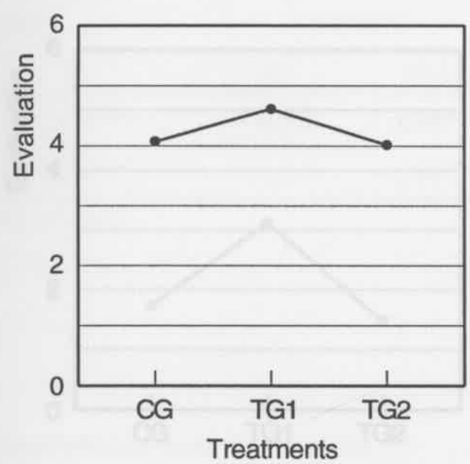


Figure 37. Group means of evaluation (Cluster 1).

the medium range ($\eta^2 = .077$) in evaluation of sustainability. The post-hoc tests found that significant differences exist between TG1 (specific information) and the rest in preference ($p < .001$) and evaluation of sustainability ($p < .001$).

In Cluster 2 (Table 23), the null hypothesis was rejected only with respect to the evaluation of

Table 23

ANOVAs of Preference and Evaluation of Sustainability (Cluster 2: Sustainable/Invisible)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)	Pref	20.00	2	10.00	4.04	.018[b]	.013	.489
	Eval	331.25	2	165.63	168.86	.000***	.347	1.000
Culture (C)[c]	Pref	1.09	1	1.09	0.44	.506	.001	.028
	Eval	0.42	1	0.42	0.43	.515	.001	.028
I x C[c]	Pref	0.28	2	0.14	0.06	.945	.000	.013
	Eval	0.35	2	0.18	0.18	.835	.001	.019
Error	Pref	1574.30	636	2.48				
	Eval	623.81	636	0.98				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] This is not significant because the level of significance was adjusted to .01.

[c] Cultural and interactional effects are discussed later.

$^{**}p < .01$. $^{***}p < .001$.

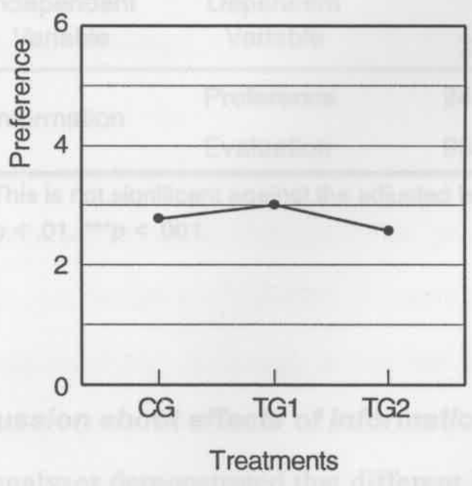


Figure 38. Group means of preference (Cluster 2).

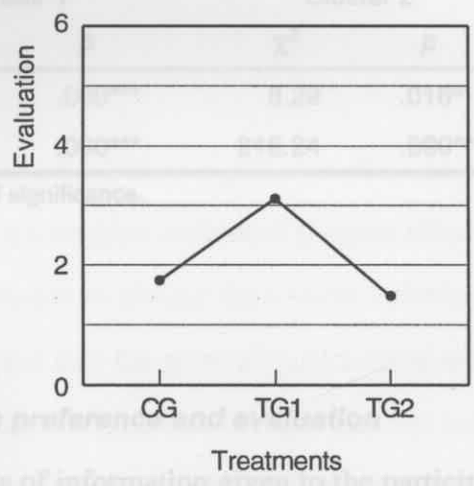


Figure 39. Group means of evaluation (Cluster 2).

sustainability. The effects of information on preference approached the adjusted level of significance, but was not significant (p = .018). The statistical power of this item (.489) indicates that the sample size was not large enough to detect the significant effect. The analysis detected a significant and large information effect (η^2 = .347) in the evaluation of sustainability due to the supply of information. The effects of specific information (TG1) is clearly evident in Figure 39. The pair-wise post-hoc tests found that there were significant differences in participants' evaluation of sustainability between TG1 and the other two groups ($p < .001$), i.e., again specific information had a significant impact on the evaluation of design examples in Cluster 2.

Table 24 summarises the results of the Kruskal-Wallis tests applied to Cluster 1 and Cluster 2. As the table indicates, the results of the Kruskal-Wallis tests are very similar to those of ANOVAs. Significant differences between the groups were found in preference in Cluster 1 and in the evaluation of sustainability in both clusters. Also, similar to the results of ANOVAs, the effects of information on Cluster 2 approached the adjusted level of significance.

Table 24

Summary of Kruskal-Wallis Tests Applied to Cluster 1 and Cluster 2

Independent Variable	Dependent Variable	Cluster 1		Cluster 2	
		χ^2	p	χ^2	p
Information	Preference	24.21	.000***	8.29	.016[a]
	Evaluation	95.73	.000***	216.24	.000***

[a] This is not significant against the adjusted level of significance.
$^{**}p < .01$. $^{***}p < .001$.

Discussion about effects of information on preference and evaluation

The analyses demonstrated that different levels of information given to the participants had significant effects on the evaluation of sustainability. Since the chosen participants were mainly first-year undergraduate students, it was expected that they would not have proper knowledge to make a correct evaluation of sustainability. Thus, the specific information, which explained functions and intentions of each design example, was expected to alter the participants' evaluation significantly. The analyses supported this hypothesis. The ANOVAs along with post-hoc tests found that the specific information given to the participants caused a significant increase in their evaluation of the sustainable design examples, and a significant decrease in evaluation of the unsustainable design examples. In all the situations, the post-hoc tests found that the differences in evaluation between CG and TG1 were highly significant ($p < .001$). The original purpose of the specific information was to change participants' evaluation of sustainability. The analyses confirmed that specific information given to them was quite effective for that purpose.

The effects of information on preference for the design examples were limited. A significant difference in preference due to information was found in the sustainable design examples. However, the effect size in this analysis indicated that the information effects on preference were small. In the case of the unsustainable design examples, despite the large difference in evaluation of sustainability (suggested by the effect size), no significant difference in preference between the groups was identified. Thus, the ANOVAs on the two groups of design examples found that the information has small or no effects on preference for the design examples presented.

The post-hoc tests found that very general information had no significant effect on evaluation of sustainability or preference. The general information emulated slogans often found in public media that are intended to encourage people to change their view, attitudes, and behaviour patterns. Although it was not expected that the general information would have effects on the participants' evaluation of sustainability, it was thought that the information might influence their environmental attitudes, which in turn might influence their preference for sustainable design. However, first of all, comparison of environmental attitudes did not find any significant differences due to the provision of general information.[9] In addition, no significant difference in preferences was found due to general information. The results indicate that slogans represented by general information provided in the study may not be effective in changing people's perception of sustainable design.

---

9. Since the NEP scale is known to be multidimensional, comparisons of attitudes were made based on three factors extracted from the scale. See Table 28 for the results of factor analysis of the NEP scale.

The analyses applied to Cluster 1 and Cluster 2 found that the way information influenced preference differs between different types of sustainable design. In Cluster 1, which includes design examples that are easily recognisable as sustainable, the information generated a significant difference in preference between the groups. Although the effect size was not large, those who were given specific information preferred the design examples in this cluster significantly more than participants from the other groups. However, in the case of Cluster 2, which contains three buildings that are sustainable but difficult to be recognised as such from images, the information effect on preference was marginal. Initially, it was anticipated that disclosing functions and effectiveness of sustainable design, which are unperceivable to lay people from photographs, would lead to increases in participants' preference. However, the effect of the information on preference was not significant according to the adjusted level of significance. It may be because people's preferences for built structures are "stable," thus conveying information regarding their advantages may have little impact. Later discussion explores this issue further.

In the previous section, the study discussed the possibility of increasing preference for the buildings in Cluster 2 by raising their "visibility." It is possible to claim that the specific information given to the participants served to improve the visibility in an indirect manner. The results found that the specific information had no significant effect on participants' preference for the image of the buildings. It can be implied from the results that improving the visibility may not be effective in changing people's preference for buildings. However, the solar house, a building with explicitly visible sustainable features, recorded a higher preference. Further study is necessary to explore the effect of the visibility in sustainable design.

It was expected that difference in evaluation of sustainability caused by information would alter participants' preference. However, the results in this section showed a limited support for this hypothesis. Despite the significant and large effect of specific information on evaluation, no significant effect was found in preference in the unsustainable design examples and in Cluster 2. People's evaluation of sustainability seemed to influence their preference for some design examples but not for others. It is fair to say that many factors are involved in people's preference judgment for something. The results of the ANOVAs imply that evaluation of sustainability is one of the factors influencing preference for sustainable design but not a strong one. The extent to which evaluation influences preference will be explored further in the next section.

Considering the information as a means of *persuasion* seems to offer some insights. Preferences for some objects are amenable to change by persuasion (Cluster 1), while those for other objects are not amenable to change by persuasion (unsustainable design examples). Zajonc and Markus (1982) commented that preference can be changed by cognitive means only in the early stage of preference formation, because "affect may become partly or fully autonomous and independent of the cognitive elements" (p. 128). It can be argued that the information was not able to alter preferences for unsustainable design examples because affect for those objects are independent of cognitive elements. Preferences for a big suburban house and green lawn are firmly embedded in our society both Japanese and Australian. Affect for these examples may have become autonomous. A similar reason may pertain to preferences for the three buildings in Cluster 2. Because of countless exposures to unattractive buildings in a long period of time, people's preference for buildings in general may have become enduring. On the contrary, in the case of preferences for the examples in Cluster 1, affective and cognitive responses may be more closely intertwined. One possible explanation for this is that some of the stimuli in Cluster 1 may look "novel" to the participants. Compared to familiar images of the suburban house, apartment, and park, the images of the wetland, sod covered house, and drainage may be something they know less about. Thus the participants may have not fully formed their preferences for those objects. According to the reasoning by Zajonc and Markus (1982), this could be one of the reasons that specific information was effective for the design examples in Cluster 1 but not for Cluster 2.

The main idea or underlying hypothesis of the thesis was that sustainable design needs to be acknowledged and preferred by people so that it may spread widely in a society. In this sense, understanding effective ways to change people's preference for sustainable design is beneficial to promote sustainability. According to the theory discussed, if preference is based on object utilities and in its early stage of formation, cognitive means of persuasion such as information may be effective to change people's preference. However, as the results of the current analyses suggest, if preference for an object has become stable, persuasion by means of information is not likely to work. Zajonc and Markus (1982) commented that "both the affective and the cognitive elements must be carefully examined, because in the end, it is affective element that must be altered" (p. 127). The present research investigated only the effect of information on preference for sustainable design. In future research, other ways of persuasion employing affective means and different types of cognitive mean may need to be identified and tested.

Models of Preferences for Sustainable Design

In the fifth question of this study, hypothetical models of preferences for sustainable design were examined. The models were constructed based on the arguments developed in this study based on the previous research related to environmental preference. Structural equation modeling (SEM) was used to test the plausibility of the models.

Hypothetical models

In the previous section, the two-way ANOVAs were used to investigate the relationships between the provision of information and evaluation of sustainability, and between the provision of information and preference. However, the analysis did not discuss the relationship between evaluation and preference. The fifth research question was to explore this relationship by constructing and testing a model that explains preferences for sustainable design. Structural equation modeling was employed for this purpose. Other than the two main variables, environmental knowledge and attitudes were also included in this analysis to construct a more comprehensive model.

Figure 40 is the model to be tested with SEM. The diagram is essentially the same as Figure 26 in Chapter 5, but drawn following conventions of SEM. This model is based on a set of hypotheses related to preferences for sustainable design. In the previous section, the ANOVAs found that information given to the participants lead to an increase cognitive evaluation for sustainable design examples. The analyses also found that the same information increased preferences for sustainable design to some extent. From these research findings and the theories discussed before in this thesis, it can be hypothesised that a change in evaluation of sustainability (EVAL) causes a change in preferences for sustainable design (PREF). The main purpose of SEM was to examine this hypothesis. The four hypotheses assessed in the analysis are summarised as follows:

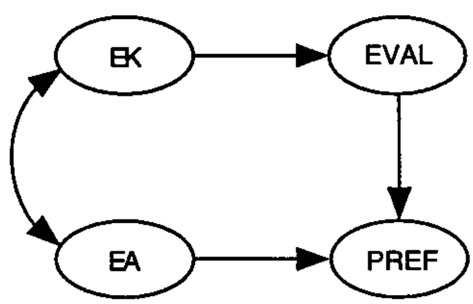
H_3: Evaluation of sustainability influences preference for sustainable design.

H_4: Environmental knowledge influences evaluation of sustainability.

H_5: Environmental attitudes influence preference for sustainable design.

H_6: Environmental knowledge and environmental attitudes are correlated with each other.

Detailed arguments related to these hypotheses are found in Chapter 4 of this thesis.



PREF: Preference for Sustainable Design
EVAL: Evaluation of Sustainability
EK: Environmental Knowledge
EA: Environmental Attitudes

Figure 40. The hypothetical model of preference for sustainable design to be tested with SEM

As results of SEM do not suggest that a model is correct or incorrect, but only suggest it's plausibility (MacCullum & Austin, 2000), an alternative model was also tested. It is recommended in the SEM literature that several alternative models be specified and evaluated to provide some protection against a confirmation bias (MacCullum & Austin, 2000; Thomson, 2000). The alternative model tested in the present study was the same as the original model shown in Figure 40 except for the reversed relationship between evaluation and preferences. In the alternative model, it was hypothesized that preferences for sustainable design influence people's evaluation of sustainability.

This alternative hypothesis has some supports from theories and the data collection procedure. First, it is possible to think that one may evaluate an object positively just because the person likes the object. This theory, which is called *cognitive consistency* in the field of risk perception, suggests that favourable affective responses toward an object can lead to positive cognitive evaluation (Alhakami & Slovic, 1994). Second, *halo bias*, which refers to inclination that overall impression of an object influences evaluation of the object in specific dimensions, may also be involved in the process (Judd et al., 1991). Finally, in the data collection process, evaluation of sustainability was measured after preference (Figure 25). Time precedence in measurement of variables can be considered as one reason to claim causality in SEM (Kline, 1998). At the time of evaluation of sustainability, some participants may have been aware of their preference ratings.

Preparation of data

In conducting SEM, sample size is an important issue. Although a review article by MacCullum and Austin (2000) on SEM reported that about one fifth of the studies they reviewed used a sample smaller than 100, it is generally considered that the minimum sample size should be between 100 and 150 cases (Klem, 2000). Another criterion for a necessary sample size in SEM is between 5 and 10 cases per a parameter to be estimated (Bentler & Chou, 1987). It turned out that 22 parameters were to be estimated in the model shown in Figure 40. For this reason, Data Set B (N = 235) were found more appropriate than Data Set A (n = 178). Accordingly, the SEM analysis included six sustainable design examples (the windmill, wetland, drainage, sod covered house, research centre, and apartment). The unsustainable design examples were not included in the analysis.

Before the analysis, it was necessary to deal with missing data and outliers. In order to retain a larger number of participants, those participants who did not answer three or more question items were considered missing (n = 12), and deleted casewise. Other missing data (n = 45) were substituted by a mean score. Outliers were also excluded from the data set. Using the same criteria in the case of the ANOVAs, six cases were considered outliers, and thus deleted casewise.[10] The final number of cases in the data set was 217.

Although the present study was experimental in research design, different levels of information were not considered as a variable in the analysis. Theoretically, it is possible to incorporate an experimental variable by conducting a separate SEM analysis for each treatment condition (MacCullum & Austin, 2000). However, this procedure proved to be difficult because of the size of subsamples. While the total number of participants used in the SEM analysis was 217, the number of participants in each control/treatment group is smaller than 100, which is below the minimum requirement.

Specification of latent variables

Factor analysis (principal component analysis with varimax rotation) was applied to specify each of the four latent variables. Since the analysis included environmental knowledge and

10. Preliminary factor analyses were conducted to identify items in each latent variable. Outliers were identified based on Z scores of mean of items belonging to factors extracted for each latent variable. The following latent variables had outliers: preference (1), environmental knowledge (1), and environmental attitudes (4). Principal component analyses after exclusion of the outliers turned out to be essentially the same as the preliminary analyses.

attitudes, the analysis is based on each participant's score. Thus, in the case of the semantic differential scale and Perceptual Sustainability Evaluation scale, mean scores of each item across the six sustainable design examples were calculated and used for the analysis.

Preference for sustainable design was considered as a latent variable in SEM contrary to the other analyses. This latent variable is designated as "PREF" in this section. Factor analysis was applied to the semantic differential scale. Items in the factor that includes the item of like–dislike were considered to measure the latent construct of PREF. Table 25 shows the results of factor analysis of the scale. The first factor included liking, attractiveness, beauty, interestingness, and efficiency. Thus a combination of these five items was considered to measure the latent variable of PREF. Unlike the factor analysis carried out earlier in the study (Table 15), efficiency was also loaded on this factor. The difference of design examples included in the analysis and the different analysis method may have caused the different factor composition. Cronbach's alpha of these items as a scale was .825.[11]

Evaluation of sustainability is labelled "EVAL" in the SEM analysis. Table 26 shows the results of factor analysis applied to the items in the Perceptual Sustainability Evaluation scale. It turned out that the scale has two interpretable dimensions for the six design examples included in this analysis. The first factor, which included items related to proenvironmental behaviour, energy saving, people's awareness for the environment, and use of natural energy, can be named "positive effects on the environment." The second factor, which contained two items associated with pressure to the environment, can be regarded as "negative effects on the environment." Internal consistencies (Cronbach's alpha) of the subscales were .838 for Factor 1 and .698 for Factor 2.

The latent variable of environmental knowledge is named "EK" in the analysis. As discussed

11. Since the data used in SEM are mean scores of the items across the design examples, reliability was calculated on the mean scores across design examples instead of each design example.

Table 25

Factor Matrix of the Semantic Differential Scale (n = 217)

Semantic Differential Items	Factor 1	Factor 2	Factor 3
Like–Dislike	.898		
Attractive–Unattractive	.882		
Interesting–Boring	.815		
Beautiful–Ugly	.781		
Efficient–Inefficient	.387		
Conspicuous–Inconspicuous		−.797	
Simple–Complex		.778	
Natural–Human made			−.753
Well maintained–Not well maintained			.644
Uncluttered–Cluttered			.587
% of variance	33.03	15.86	13.45

Table 26

Factor Matrix of the Perceptual Sustainability Evaluation Scale

Items in the Perceptual Sustainability Evaluation Scale	Factor 1	Factor 2
6. raising people's awareness toward the environment	.847	
4. accompanying human activities caring for the environment	.831	
1. making use of natural energy	.720	
5. requiring little energy to maintain	.710	
2. constructed with low impact on the environment		.922
3. having negative environmental effects on surroundings		.695
% of variance	58.34	13.74

previously, two items in the scale were dropped to obtain higher reliability. Table 27 indicates the results of factor analysis of the Environmental Knowledge scale. This latent construct was considered unidimensional.[12]

12. Eigenvalue suggested a two-factor solution. However, since the factors did not provide meaningful interpretation, a one-factor solution was adapted.

Table 27

Results of Factor Analysis of the Environmental Knowledge Scale

Items in the Environmental Knowledge Scale	Loading
5. The world climate will probably massively change if CO_2 continues to be emitted into the atmosphere in as huge amounts as it is now.	.711
6. Melting of the polar ice caps may result in a flooding of shores and islands.	.710
7. A reduced number of species may interrupt the food chain, affecting some subsequent species in the chain.	.707
2. Poisonous metals are introduced into the food chain, for instance, via ground water.	.592
8. Fossil fuels (e.g. gas, oil) produce CO_2 in the atmosphere when burned.	.519
4. Poisonous metals remain in the human body.	.496
3. A change in climate caused by increased levels of CO_2 in the atmosphere is called the greenhouse effect.	.401

The latent variable of environmental attitudes is described as "EA" in the analysis. Table 28 shows the results of factor analysis applied to the NEP scale. Three factors were extracted in factor analysis of the scale. The first factor is concerned with the idea of human's ascendancy over the rest of nature. The second factor includes the items related to balance, limit, and harmony, which suggested the importance of stability of the environment. The third factor embraces the ideas of human pressure on the environment, which is ever increasing and reaching the maximum capacity the earth can hold. Cronbach's alphas of the three subscales were .661 for Factor 1, .549 for Factor 2, and .566 for Factor 3. These reliabilities seemed low against the standard recommended by Nunnally (1978). This may cause some problems in the analysis of structural models. This issue will be touched later.

Structural models

The principal component analyses identified items that measure each latent variable. In the case of PREF and EK, 5 and 7 items were found to measure the latent variables respectively. In the structural model assessed in this study, an "item parcel," which is a composite of items,

Table 28

Results of Factor Analysis of the NEP Scale

Factor 1: Human domination over nature (26.56% of variance)	Loading
10. Plants and animals exists primarily to be used by humans.	.757
9. Humans have the right to modify the natural environment to suit their needs.	.730
2. Humans were created to rule over the rest of the nature.	.721
12. Humans need not adapt to the natural environment because they can remake it to suit their needs.	.513
Factor 2: Stability of the environment (12.50% of variance)	
8. The balance of nature is very delicate and easily upset.	.705
7. The earth is like a spaceship with only limited room and resources.	.642
5. To maintain a healthy economy, we will have to develop a 'steady-state' economy where industrial growth is controlled.	.589
6. Humans must live in harmony with nature in order to survive.	.589
Factor 3: Human pressure to the environment (10.08% of variance)	
3. There are limits to growth beyond which our industrialized society cannot expand.	.720
1. When humans interfere with nature, it often produces disastrous consequences.	.664
11. We are approaching the limit of the number of people the earth can support.	.553
4. Humans are severely abusing the environment.	.527

was employed as a measured variable. In both cases of PREF and EK, two parcels were constructed, which were titled "pref1," "pref2," "ek1," and "ek2." In each latent variable, the items were divided into two parcels according to their factor loadings.[13] A mean score of the items belonging to the parcel was used as a measured variable in structural models. The reason for using the item parcels is that by combining several items into a parcel, it is possible to reduce the number of parameters to be estimated in a structural model. This means that the

13. Composition of items in a parcel was decided by the order of factor loadings. In PREF, the first, fourth, and fifth items in the factor matrix (liking, beauty, and efficiency) were used to calculate pref1, while the second and third items (attractiveness and interestingness) were included in pref2. In EK, the first, fourth, sixth, and seventh items in the factor matrix (questions 2, 3, 4, and 5) belonged to ek1, and the second, third, and fifth items (question 6, 7, and 8) constituted ek2.

use of item parcels enables researchers to test a structural model with a relatively small sample (West, Finch, & Curran, 1995).

In the case of EVAL and EA, the factors analyses identified several dimensions. Items in these latent variables were divided according to the theoretical concepts suggested by the factor analyses. Similar to the items parcels, a mean score of items in each factor was computed and used as a measured variable in structural models. Factors 1 and 2 of EVAL were labelled "eval1" and "eval2." Factors 1 to 3 of EA were named "ea1," "ea2," and "ea3." Table 29 shows mean (*M*), standard deviation (*SD*), skewness, and kurtosis of these measured variables (parcels and factors) used in structural models and their bivariate correlation coefficients. As the table indicates, no excessive skewness and kurtosis were detected.

To estimate parameters in the structural model, the maximum likelihood method was employed in this study. Figure 41 shows the structural model and the results of the analysis (standardised parameter estimates). This structural model is labelled Model 1. In the model, an oval signifies a latent variable, while a rectangle is a measured variable. A single-sided arrow connecting variables signifies a directional relationship between variables, and a curved double-sided arrow connecting variables denotes nondirectional association between them. An arrow pointing to a measured variable (without connecting two variables) indicates a sum of error and unique variance of the measured variable, while an arrow pointing to a latent variable signifies unaccounted variance of the latent variable, which is equivalent to residual variance in regression analysis.

Figure 41 shows that the model explained 34 percent of the variance of PREF by EVAL (β = .54) and EA (β = .16).[14] The path coefficient from EVAL to PREF was highly significant ($p < .001$) and that from EA to PREF had a borderline significance ($p = .045$). It was also indicated that three percent of the variance of EVAL was explained by EK (β = .16) . How-

14. β (standardized regression coefficient) is used to describe path coefficients.

Table 29

Bivariate Correlations between the Measured Variables and their Mean, Standard Deviation, Skewness, and Kurtosis

	Bivariate Correlations												
	1	2	3	4	5	6	7	8	9	*M*	*SD*	Skewness	Kurtosis
1. pref1	1.									3.497	0.612	0.274	0.222
2. pref2	.746***	1.								3.462	0.805	–0.020	0.539
3. eval1	.499***	.414***	1.							3.539	0.709	0.423	–0.191
4. eval2	.343***	.269***	.595***	1.						3.615	0.659	0.307	0.184
5. ea1	.048	.092	.002	–.005	1.					4.664	1.023	–0.666	–0.201
6. ea2	.148*	.159*	.139*	.015	.216**	1.				4.704	0.781	–0.467	0.426
7. ea3	.065	.121	–.021	–.126	.336***	.342***	1.			4.532	0.837	–0.487	–0.146
8. ek1	.131	.101	.134*	.069	.230**	.435***	.392***	1.		4.594	0.766	–0.235	–0.725
9. ek2	.206**	.211**	.149*	.037	.208**	.513***	.373***	.480***	1.	4.999	0.779	–0.743	0.156

Note: $n = 217$.

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

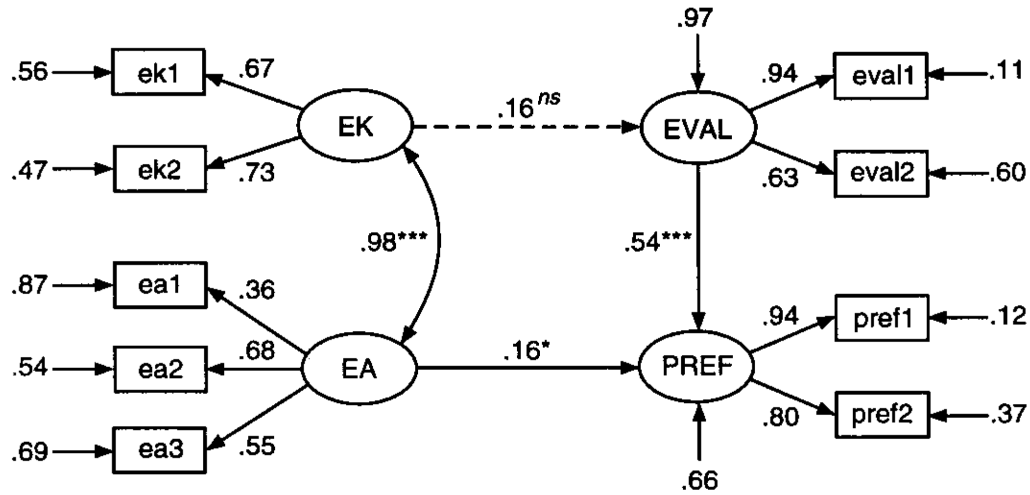


Figure 41. Model 1: Structural model explaining preference for sustainable design (PREF) by evaluation of sustainability (EVAL), environmental knowledge (EK), and environmental attitudes (EA).
*$p < .05$. ***$p < .001$.

ever, the path from EK to EVAL was not significant ($p = .056$). A strong and significant correlation between EK and EA ($r = .98, p < .001$) was also found in the analysis.

The overall model fit was assessed with several indices: $\chi^2 = 27.61$, df = 23 (χ^2/df = 1.200), goodness-of-fit index (GFI) = .972, Tucker-Lewis index (TLI) = .987, comparative fit index (CFI) = .992, and root mean square error of approximation (RMSEA) = .030. Recommended criteria of a good fit in the above indices are χ^2/df < 2.5 (Kline, 1998), GFI > .95 when a sample size is below 250, TLI > .95, CFI > .95, and RMSEA < .06 (Hu & Bentler, 1995, 1999). All the indices obtained suggest that the hypothetical model represents an adequate fit to the data.

One problem of Model 1 is a very strong correlation between EK and EA. This suggests that EK and EA are essentially the same construct. The bivariate correlation between environmental knowledge (mean of seven items) and environmental attitudes (mean of 12 items) was not very strong ($r = .548, p < .001$) compared to the correlation coefficients derived in this analysis ($r = .98$). However in SEM, a latent variable is not a simple sum of measured variables but a common variance shared by them. Large residual (unique and error variance) of ea1 (.87) and ea3 (.69) suggests that these two indicators are contributing to EA only partially. Thus it can be assumed that after exclusion of the large residuals, EK and EA happened to measure the same construct. It may be possible that the low reliabilities in the subscales of EA and EK might have been responsible for the redundancy of EK and EA.

In this situation, it is possible to combine two latent variables into one latent variable (Kline, 1998). A new structural model, Model 2, in which one latent variable (EK/EA) with five measured variables was employed, is shown in Figure 42. Similar to Model 1, thirty-four percent of the variance of PREF was predicted by EVAL ($\beta = .54, p < .001$) and EK/EA ($\beta = .16, p < .05$) in the new model. The parameter estimates in Model 2 are almost identical to those shown in Model 1. The overall model fit indices were: $\chi^2 = 27.67$, df = 24 (χ^2/df = 1.153), GFI = .972, TLI = .990, CFI = .993, and RMSEA = .027. Since Model 2 is more parsimonious, and has a slightly better fit to the data, the following discussion is based on the results of Model 2.

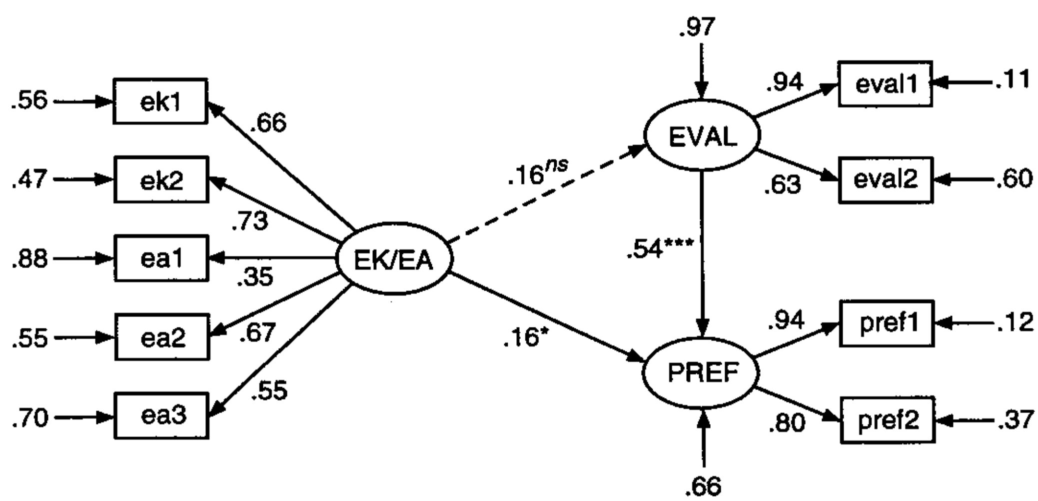


Figure 42. Model 2: Structural model explaining preference for sustainable design (PREF) by evaluation of sustainability (EVAL) and environmental knowledge/attitudes (EK/EA).
*$p < .05$. ***$p < .001$.

An alternative model was constructed based on Model 2. The alternative model, Model 2a, and its parameter estimates are shown in Figure 43. Thirty-two percent of the variance of EVAL was explained by PREF ($\beta = .56, p < .001$) in this model. Six percent of the variance of PREF was predicted by EK/EA ($\beta = .25, p < .05$). The fit indices of this model were identical to those obtained in Model 2.

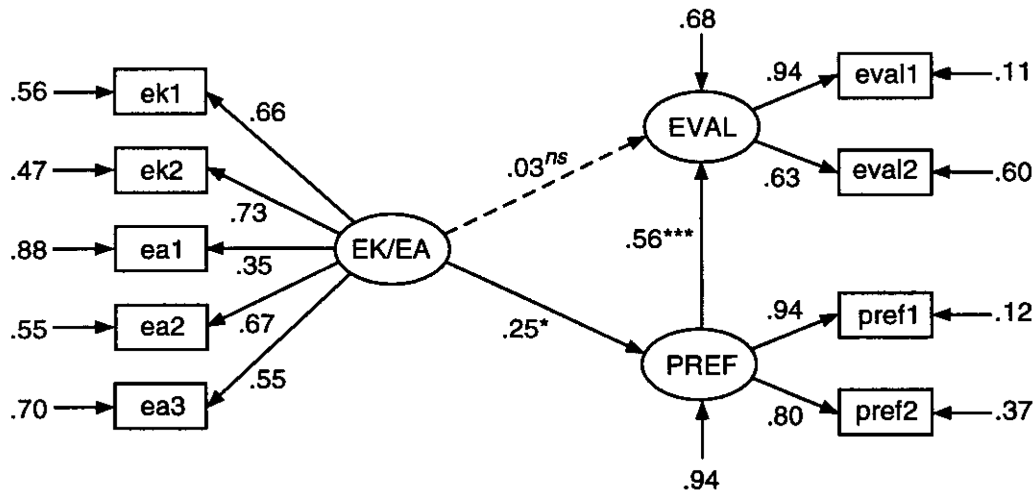


Figure 43. Model 2a: Structural model explaining evaluation of sustainability (EVAL) by preference for sustainable design (PREF) and environmental knowledge/attitudes (EK/EA).
*p < .05. ***p < .001.

Discussion about models of preferences for sustainable design

It has to be mentioned before discussion that the integration of EK and EA in the structural model can be considered a data-driven model modification. There are concerns about model modifications driven by data, since it may result in altering the model to fit peculiarities of a particular sample (e.g., Klem, 2000). This makes generalisation of the model questionable, especially when a sample size is not large (MacCallum, Roznowski, & Necowitz, 1992). Although the model modification made in the current analysis did not aim to improve model fit, it is acknowledged that the modified model may not apply to other samples.

The results of the SEM analysis (Model 2) support the hypothesis regarding the effect of evaluation of sustainability on preference. The analysis found that EVAL has a highly significant and relatively large effect on PREF. It was also found that one third of the total variance of PREF was accounted for by two predictors, EVAL and EK/EA. Model fit indices suggest that the hypothetical model fits quite well to the data. Thus it can be argued that the two different types of analyses (ANOVA and SEM) agree in suggesting the influence of evaluation of sustainability on preference for sustainable design.

The results also support the hypothesis concerning the effect of environmental attitudes on preference, although the path coefficient was small ($\beta = .16$) and had a borderline significance ($p = .045$). Several reasons for the weak relationship can be pointed out. As Table 29 indicates, bivariate correlation coefficients between two parcels of PREF (pref1 and pref2) and the three factors of EA (ea1, ea2, and ea3) are rather small (between .048 and .159). In addition, in the case of the buildings in Cluster 2, a negative significant correlation between environmental attitudes and preference ($r = -.18, p < .01$) was found.[15] It is possible to infer that without proper knowledge of functions and intentions of these buildings, participants who espouse proenvironmental attitudes tend to dislike these buildings. This implies that the relationship between preference and environmental attitudes may be mediated by environmental knowledge. Exploring this relationship appears to provide some insights into perception of sustainable design. However, due to the unification of EK and EA in this analysis, investigation of this relationship needs to wait until future research.

The hypothesis of environmental knowledge as a predictor of evaluation of sustainability was not supported in the analyses. The path from EK/EA to EVAL was not significant ($p = .073$). A possible reason for this phenomenon lies in the difference in knowledge necessary

15. The correlation coefficient between a mean preference for two images (the research centre and apartment) and participants' mean attiudes sccore was calculated ($n = 230$).

to answer the questions items in the scale of environmental knowledge and that required to answer the items in the Perceptual Sustainability Evaluation scale. Even if one has an extensive knowledge on general environmental issues such as global climate change and loss of biodiversity, it dose not necessarily mean that the person is very knowledgeable about means to resolve these issues. In a model of environmentally responsible behaviour, Hines et al. (1986/87) treated knowledge of problems and knowledge of strategies to deal with the problems separately. The two types of necessary knowledge also differ in the scale: one is global (environmental knowledge) and the other is local (evaluation of sustainability). It is possible to argue that these differences in the nature of knowledge is partly responsible for the insignificant relationship between EK/EA and EVAL.

Model fit indices found that Model 2 and Model 2a fit the data exactly to the same degree. The alternative hypothesis in Model 2a, a causal effect of preference on evaluation of sustainability, was also supported. As discussed before, this rival hypothesis also has some supports from theories as well as the data collection procedure. Based on the results of SEM alone, therefore, it is not possible to decided which model (Model 2 or Model 2a) better represents the data. It has to be concluded that Model 2a is as plausible as Model 2.

The results of the ANOVAs provide a clue to resolve the situation. The ANOVAs found large effects of information on evaluation of sustainability but rather small effects on preference. Considering the directionality between the two variables, it seems reasonable to assume that a large evaluation change causes a small change in preference. However, it is unlikely that a small change in preference causes a large difference in evaluation of sustainability. Path coefficients β between PREF and EVAL were around .5 in both models. This coefficient ($\beta = .5$) means that a change equivalent to one standard deviation in a predictor variable causes a change equivalent to .5 of standard deviation in a criterion variable. Thus the path coefficient is also consistent with the assumption that the a large change in evaluation leads to a small change in preference. Therefore, it can be argued that the results from Model 2 of the

SEM analysis are consistent with the results of the ANOVAs. Thus, it can be argued that the results from the SEM analysis suggest that a change in participants' evaluation of sustainability causes a change in their preferences for sustainable design.

The results of the study support the hypothesis concerning the causal effect of cognitive evaluation of sustainability on preference for sustainable design. It is now possible to say that increasing people's evaluation of sustainability is one way to heighten their preferences for sustainable design. However, the effect of evaluation on preference is not very strong. The structural model indicates that only one third of the variance of preference was explained by evaluation of sustainability, environmental knowledge, and attitudes. This means that two thirds of the variance of preference are controlled by some other determinants. Further empirical research is necessary to explore those determinants to develop more effective means to influence people's preferences for sustainable design.

Cultural Comparisons

The final question of this research was cultural comparisons between the Japanese and the Australian participants. In order to examine the degree of similarities in terms of preference and cognitive evaluation between the two samples, bivariate correlations were calculated. To explore differences between them, the results of the two-way ANOVAs conducted in the previous section were presented again and interpreted. The following hypothesis was of particular interest in this part of the thesis.

H_7: If cultural differences in preferences for sustainable design between Japanese and Australian respondents exist, they are due to differences in cognitive evaluation of sustainable design.

Bivariate correlations

Tables 30 and 31 show the number of valid responses (*n*), mean (*M*), and standard deviation (*SD*) of preference and evaluation scores of the Japanese and Australian participants for each

Table 30

Preference Ratings of the Japanese and Australian Samples

		Japanese			Australian		
No	Design example	*n*	*M*	*SD*	*n*	*M*	*SD*
1	Windmill	128	4.586	1.233	107	4.336	1.303
2	Wetland	128	3.805	1.511	107	3.804	1.444
3	Pond	71	3.634	1.447	106	3.972	1.411
4	Solar House	71	3.803	1.440	107	3.458	1.568
5	Drainage	128	3.742	1.300	106	4.047	1.457
6	Sod covered house	128	3.547	1.541	106	3.094	1.665
7	Commerical complex	71	3.254	1.592	107	2.785	1.812
8	Research centre	128	2.828	1.392	106	2.906	1.721
9	Apartment	127	2.480	1.368	107	2.794	1.577
10	Suburban house	128	4.203	1.324	106	3.481	1.581
11	Park	128	3.836	1.494	107	3.850	1.491

Table 31

Evaluation Scores of the Japanese and Australian Samples

		Japanese			Australian		
No	Design example	*n*	*M*	*SD*	*n*	*M*	*SD*
1	Windmill	128	4.741	0.779	106	4.867	0.804
2	Wetland	128	4.288	0.877	106	4.360	0.805
3	Pond	71	4.398	0.917	106	4.520	0.805
4	Solar House	71	3.918	1.148	106	3.835	1.193
5	Drainage	127	4.133	0.938	107	4.079	1.018
6	Sod covered house	128	3.907	0.969	106	3.747	1.008
7	Commerical complex	71	2.575	1.247	106	2.284	1.247
8	Research centre	128	2.225	1.333	107	2.134	1.263
9	Apartment	128	2.061	1.137	106	1.964	1.084
10	Suburban house	128	2.075	1.030	107	1.786	0.907
11	Park	128	2.438	1.200	106	3.164	1.299

design example. The correlations in preference and cognitive evaluation between the two culture groups show the degree of agreement between them. The bivariate correlation coefficient of mean preference between the Japanese and Australian samples was .847 ($p < .01$) in the case of the sustainable design examples. The same coefficient in mean evaluation score was .996 ($p < .001$). Slightly lower but still significant correlation coefficients were obtained when all the design examples were included. In this case, the correlation coefficients in preference and in evaluation were .799 ($p < .01$) and .969 ($p < .001$) respectively. These figures indicate a very high degree of agreement in preferences and evaluation of sustainability between the two culture groups.

Figures 44 and 45 are scatter plots of mean preference and evaluation scores of the Japanese and Australian participants. These are graphic representations of the mean scores shown in Tables 30 and 31. Correlation coefficients between preference and evaluation for the sustainable design examples were .918 ($p < .001$) for the Japanese sample and .921 ($p < .001$) for the Australian sample. The similar coefficients also suggest the similarity in responses to sustainable design between the two culture groups. However, differences were also found. As Figures 43 and 44 suggest, the distribution of the design examples appears different between the two groups. The Japanese and Australian groups seemed to differ in their responses to the unsustainable design examples (in particular, the suburban house). In fact, the correlation coefficients between preference and evaluation of all the design examples were .546 (*ns*) for the Japanese sample and .780 ($p < .01$) for the Australian sample. To inspect the differences between the two culture groups, the results of the ANOVAs conducted earlier in this chapter are examined in the following section.

Analysis of variance

In the earlier section of this chapter, a series of two-way ANOVAs was conducted to examine the effect of different levels of information on evaluation and preference. In the analyses, culture was also included as an independent variable. In this section, using the results from

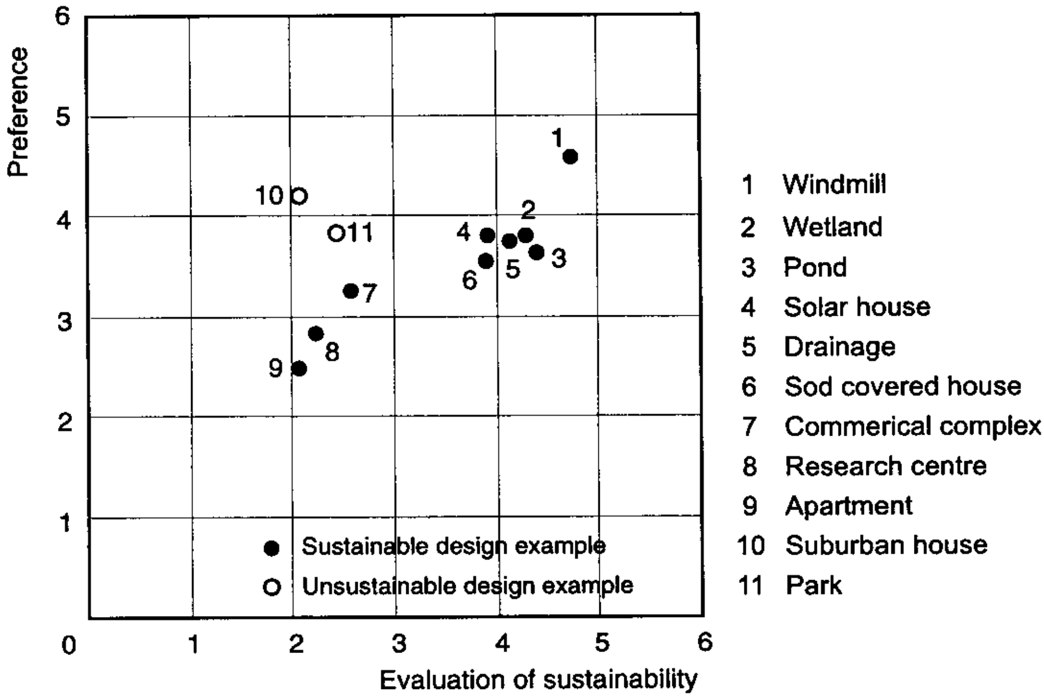


Figure 44. Scatter plot of mean preference and evaluation of sustainability of the design examples (Japanese sample).

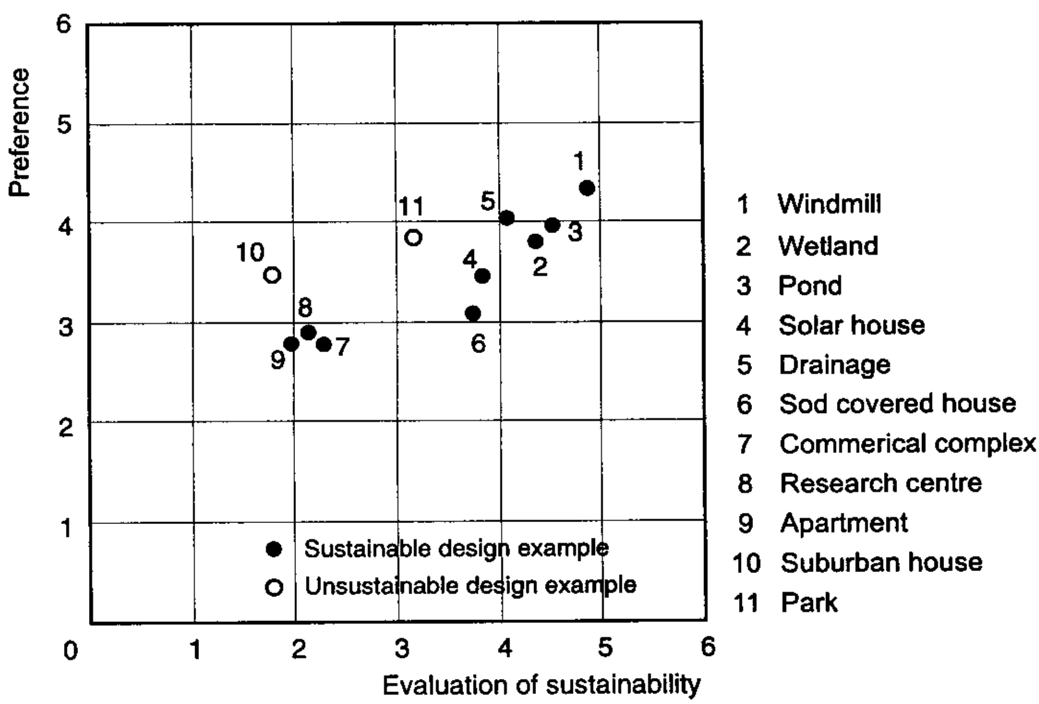


Figure 45. Scatter plot of mean preference and evaluation of sustainability of the design examples (Australian sample).

the same analyses, the study examines cultural differences in preference and evaluation. The null hypotheses tested were (1) there will be no difference in participants' preference and evaluation of sustainability according to their cultural backgrounds (Japanese and Australian), and (2) there will be no influence on participants' preference and evaluation of sustainability associated with the joint effects of information and culture. These hypotheses were examined in the following four conditions: sustainable design examples, unsustainable design examples, Cluster 1, and Cluster 2.

Tables 32, 33, 35, and 36 are the same as the tables shown in the section discussing the effects of different levels of information (Tables 19, 20, 22, and 23). A shaded area in these tables shows the effects of information about sustainability which has been discussed already. Tables 34 and 37 show the results of Kruskal-Wallis tests applied to the same data with culture as the independent variable. These nonparametric tests were conducted to further explore the results of the ANOVAs. Figures 46 to 53 are graphic representations of mean preference and evaluation scores of two subsamples in the above four conditions.

Table 32 shows the results of the ANOVAs applied to the sustainable design examples. The analyses did not find any significant differences in preference and evaluation of sustainability between the Japanese and Australian participants. No significant interaction of information and culture was found. Figure 46 shows intersecting lines, which suggests some interactional effects. However the interactional effect of the two independent variables on preference was not significant ($p = .086$).

Table 33 shows the results of the same analysis in the case of the unsustainable design examples. A significant cultural difference was found in preferences. As Figure 48 illustrates, preferences for the unsustainable design examples by the Japanese participants were higher than those by the Australian participants. However, its effect size ($\eta^2 = .017$) was small. Culture did not have any significant effects on evaluation of sustainability. No significant

Table 32

ANOVAs of Preference and Evaluation of Sustainability (Sustainable Design Examples)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)[b]	Pref	64.98	2	32.49	13.02	.000***	.013	.986
	Eval	339.63	2	169.81	88.35	.000***	.084	1.000
Culture (C)	Pref	0.66	1	0.66	0.27	.606	.000	.021
	Eval	0.78	1	0.78	0.41	.524	.000	.027
I x C	Pref	12.25	2	6.13	2.45	.086	.003	.266
	Eval	0.72	2	0.36	0.19	.830	.000	.020
Error	Pref	4782.89	1916	2.50				
	Eval	3682.64	1916	1.92				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] The information effects have been discussed previously.

$^{**}p < .01$. $^{***}p < .001$.

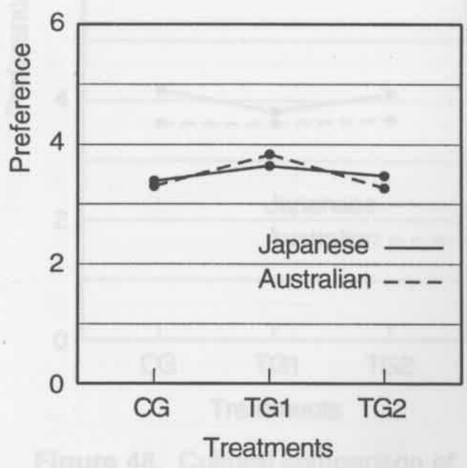


Figure 46. Cultural comparison of group means of preference (Sustainable design examples).

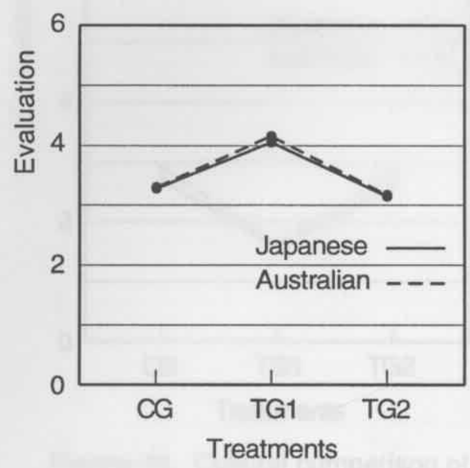


Figure 47. Cultural comparison of group means of evaluation (Sustainable design examples).

joint effects of information and culture were found in the unsustainable design examples.

Table 34 shows the results of Kruskal-Wallis tests, which examined differences in preference and evaluation scores due to different cultures. The analyses produced similar results to the

Table 33

ANOVAs of Preference and Evaluation of Sustainability (Unsustainable Design Examples)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)[b]	Pref	3.42	2	1.71	0.79	.454	.003	.064
	Eval	135.99	2	68.00	59.50	.000***	.206	1.000
Culture (C)	Pref	17.54	1	17.54	8.12	.005**	.017	.604
	Eval	3.17	1	3.17	2.78	.096	.006	.180
I x C	Pref	2.84	2	1.42	0.66	.519	.003	.052
	Eval	0.72	2	0.36	0.31	.731	.001	.027
Error	Pref	991.64	459	2.16				
	Eval	524.56	459	1.14				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] The information effects have been discussed previously.

**$p < .01$. ***$p < .001$.

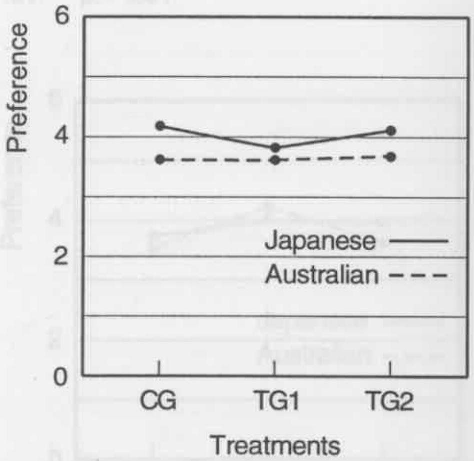


Figure 48. Cultural comparison of group means of preference (Unsustainable design examples).

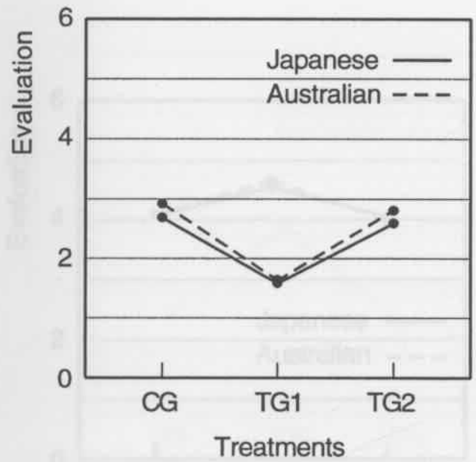


Figure 49. Cultural comparison of group means of evaluation (Unsustainable design examples).

Table 34

Summary of Kruskal-Wallis Tests Applied to Sustainable and Unsustainable Design Examples

Independent Variable	Dependent Variable	Sustainable Design χ^2	Sustainable Design *p*	Unsustainable Design χ^2	Unsustainable Design *p*
Culture	Preference	0.02	.892	7.15	.007**
	Evaluation	0.05	.820	3.02	.082

**$p < .01$.

Table 35

ANOVAs of Preference and Evaluation of Sustainability (Cluster 1: Sustainable/Visible)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)[b]	Pref	55.27	2	27.63	12.85	.000***	.020	.984
	Eval	94.14	2	47.07	53.41	.000***	.077	1.000
Culture (C)	Pref	3.06	1	3.06	1.42	.233	.001	.083
	Eval	0.38	1	0.38	0.43	.514	.000	.028
I x C	Pref	16.79	2	8.40	3.91	.020[c]	.006	.472
	Eval	1.46	2	0.73	0.83	.438	.001	.067
Error	Pref	2739.01	1274	2.15				
	Eval	1122.71	1274	0.88				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] The information effects have been discussed previously.

[c] This is not significant because the level of significance was adjusted to .01.

$^{**}p < .01$. $^{***}p < .001$.

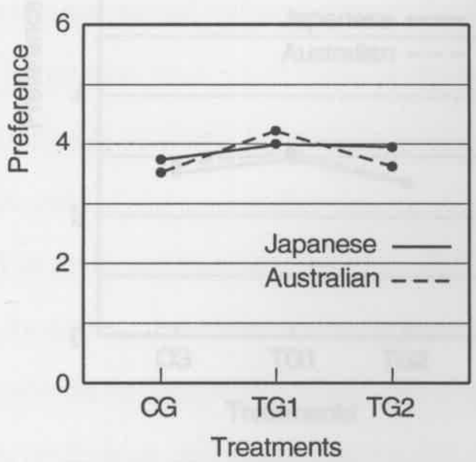


Figure 50. Cultural comparison of group means of preference (Cluster 1).

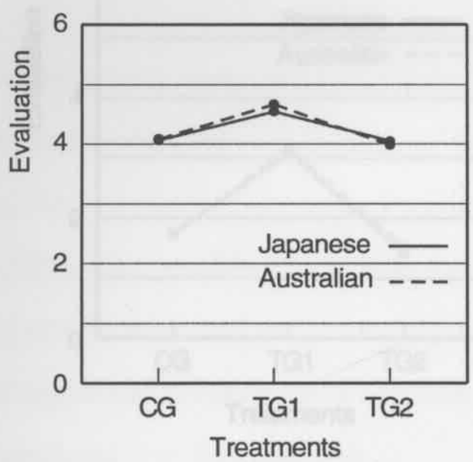


Figure 51. Cultural comparison of group means of evaluation (Cluster 1).

ANOVAs shown in Tables 32 and 33. A significant cultural difference was found only in preferences for the unsustainable design examples.

The results of the ANOVAs applied to Cluster 1 are shown in Table 35. No significant

Table 36

ANOVAs of Preference and Evaluation of Sustainability (Cluster 2: Sustainable/Invisible)

Source	DV[a]	*SS*	*df*	*MS*	*F*	*p*	η^2	power
Information (I)[b]	Pref	20.00	2	10.00	4.04	.018	.013	.489
	Eval	331.25	2	165.63	168.86	.000***	.347	1.000
Culture (C)	Pref	1.09	1	1.09	0.44	.506	.001	.028
	Eval	0.42	1	0.42	0.43	.515	.001	.028
I x C	Pref	0.28	2	0.14	0.06	.945	.000	.013
	Eval	0.35	2	0.18	0.18	.835	.001	.019
Error	Pref	1574.30	636	2.48				
	Eval	623.81	636	0.98				

[a] "Pref" and "Eval" signify preference and evaluation of sustainability respectively.

[b] The information effects have been discussed previously.

$^{**}p < .01$. $^{***}p < .001$.

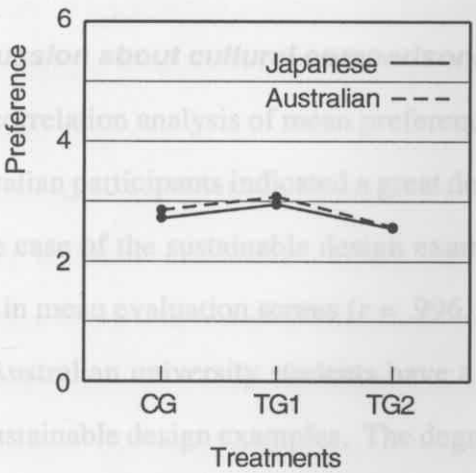


Figure 52. Cultural comparison of group means of preference (Cluster 2).

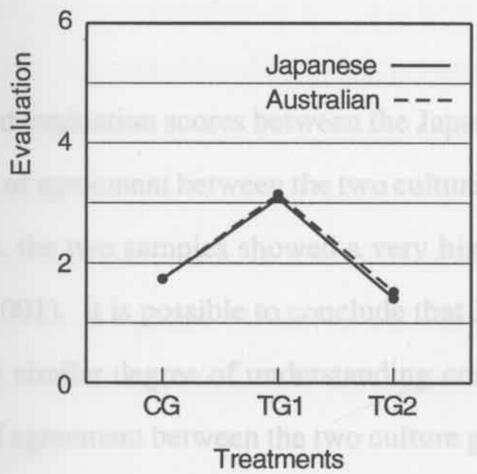


Figure 53. Cultural comparison of group means of evaluation (Cluster 2).

cultural differences were observed in both dependent variables. Intersecting lines in Figure 50 suggest that the extent to which information influences preference may be different between the two culture groups. However, this interactional effect of information and culture was found to be insignificant ($p = .020$) against the adjusted level of significance ($p < .01$).

Table 36 shows the results of the ANOVAs applied to Cluster 2. No significant cultural and interactional effects were found in this case. Table 37 indicates the results of Kruskal-Wallis tests applied to Cluster 1 and Cluster 2. The nonparametric tests indicate the same results as the ANOVAs. No cultural differences were found in preference and in evaluation of sustainability in either case.

Table 37

Summary of Kruskal-Wallis Tests Applied to Cluster 1 and Cluster 2

Independent Variable	Dependent Variable	Cluster 1		Cluster 2	
		χ^2	*p*	χ^2	*p*
Culture	Preference	0.63	.428	0.13	.720
	Evaluation	0.39	.534	1.12	.291

$^{**}p < .01$. $^{***}p < .001$.

Discussion about cultural comparisons

The correlation analysis of mean preference and evaluation scores between the Japanese and Australian participants indicated a great degree of agreement between the two culture groups. In the case of the sustainable design examples, the two samples showed a very high agreement in mean evaluation scores ($r = .996, p < .001$). It is possible to conclude that Japanese and Australian university students have a very similar degree of understanding concerning the sustainable design examples. The degree of agreement between the two culture groups in mean preference was slightly lower but still significant ($r = .847, p < .01$).

The results of the ANOVAs also suggest that the Japanese and Australian samples were very similar in their preferences for and evaluation of the design examples. A difference between them was found in preference for unsustainable design examples, however the magnitude of the difference was small. The way the information about sustainability influenced preference and evaluation of sustainability was also similar between the two culture groups, although a marginal interactional effect was found in preferences for the stimuli in Cluster 1. This also seems to suggest that the Japanese and Australian participants have a similar degree of understanding to assess the information concerning sustainable design. Cultural comparisons produced more similarities between the Japanese and Australian samples than differences.

The hypothesis proposed earlier in this section was that if a cultural difference in preferences exist, it is due to a difference in evaluation of sustainability between the two culture groups. A significant cultural difference was detected in preferences for the unsustainable design examples, which included the suburban house and park. However, as the ANOVA (Tables 33) and Kruskal-Wallis test (Table 34) indicate, no significant difference in evaluation of sustainability was found between the Japanese and Australian samples in the case of the unsustainable design examples. Thus the analysis did not support the above hypothesis.

In order to understand a reason for the rejection of the hypothesis, it is worth reviewing the relationships between affect and cognition again. The previous discussion pointed out that affective response to the environment tends to be common across cultures, and cognitive reaction is somewhat dependent on personal factors including cultural background. As preference includes both affect and cognition, a cultural difference in preference was hypothesised to occur as a result of a difference in cognitive response. However, since this hypothesis was rejected, a different explanation is needed to understand the cultural difference in preferences for the unsustainable design examples.

Zajonc and Markus (1982) pointed out that "learned" preference can become independent of cognition through a long period of exposure to, habituation in, and reinforcement from particular social surroundings. Thus, people in one sociocultural milieu may develop and share preferences for a particular object, which are independent of cognition. This may be the case for the difference in preferences for the unsustainable design examples (in particular, the suburban house). Due to the differences in sociocultural surroundings between Japan and Australia, people from the two countries may have developed different preferences for various objects. This indicates that a cultural difference in preference for an object does not necessarily involve different cognitive responses. It can be understood as expression of different cultural wants and needs.

In summary, cultural comparisons revealed that the Japanese and Australian participants are quite similar in their responses to sustainable design except for a few instances. The information given to the participants also influenced the two culture groups in the same way. However, the comparisons were made based on participants' responses to clusters of design examples. Responses to individual examples in Figures 44 and 45 suggested cultural differences in some of the examples. More focused studies are necessary to investigate attributes of sustainable design that may cause cultural differences in the perceptions of sustainable design.

Chapter Seven

CONCLUSION

Summary of the Research Findings

This study has investigated people's perceptions of sustainable design and some of the socio-psychological influences on people's preference for sustainable design. Through the investigation of the six research questions, the study has explored several factors influencing people's preferences. In addition, the study has examined seven theory-based hypotheses involving preferences for sustainable design. This section summarises the research findings from the exploratory and confirmatory investigations.

First, the exploratory part of the study found that Japanese and Australian participants tend to prefer design examples that they consider sustainable. As reviewed in Chapter 5, there are two conflicting theories concerning people's preferences for sustainable design in the literature on environmental preference. One theory maintains that sustainable design tends to be less preferred, while the other theory suggests that sustainable design is preferred because of its contribution to people's well-being. The findings of this study support the latter. Strong and significant correlations between the evaluation of sustainability and preference indicate that design examples rated high in terms of evaluation of sustainability tend also to be more highly preferred.

Second, the findings indicate the importance of cultural values of people in preferences for sustainable design. Two design examples, which were designed to fulfill cultural expectation of people without considering sustainability, were included in the stimuli. Preferences for these examples were high, even though their scores in terms of evaluation of sustainability were low. This suggests that the extent to which the environment is in conformity to one's cultural values is strongly associated with people's preference judgments. The research literature on environmental preference also underlined the importance of people's cultural values and needs in preferences for the environment.

Third, the classification of the design examples revealed that the sustainable design examples were divided into two groups. A criterion that set the examples apart seems to be what we can call the "visibility of sustainability." In one cluster of design examples, sustainability was highly visible, while in the other cluster, the evidence of sustainability was almost invisible to the participants. These two clusters were distinctively different from each other in terms of preferences and evaluation of sustainability. The "visible" examples are considered more sustainable and more preferred, whereas the "less visible" examples are considered less sustainable and less preferred. Thus, the visibility of sustainability makes a decisive difference in the perception of sustainable design.

Fourth, analysis of the data suggested that "preference," "plainness," and "tidiness" are salient perceptual factors in sustainable design. The factor of tidiness, which also included perception of care and efficiency, was positively correlated with preference. This means that people like environments they consider tidy and cared for, but like less environments they consider untidy and abandoned. It can be argued that tidy environments are in conformity to cultural values as discussed above. The factor of plainness, which is related to the formal quality of the environment, is independent of preferences.

Further examination of the factor of tidiness reveals the mixed role of naturalness in the perception of sustainable design. As the study reiterates throughout the text, the common knowledge in environmental preference research is that people prefer "natural" scenes over "built" scenes. The research findings of the current study suggests that naturalness also gives people the impression of untidiness, which is negatively correlated with preference. This indicates that the perception of naturalness is multidimensional in terms of its effects on preference.

In summary, the exploratory part of the current research found that people's preferences for sustainable design involve many interrelating perceptual factors. The factors include their evaluation of sustainability, the visibility of sustainability, the conformity of a sustainable design to cultural values, along with perceived tidiness and naturalness. Figure 54 summarises the relationships between these factors found in this study. A single-sided arrow signifies possible influence and a double sided arrow signifies possible correlation between factors. All the relationships in this diagram are positive influence or correlation except for the negative correlation between naturalness and tidiness.

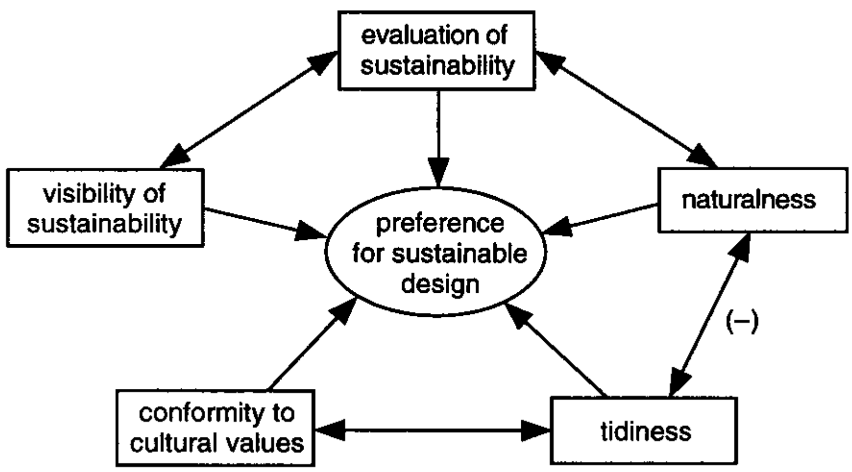


Figure 54. Implied factors involved in prefernences for sustainable design and their interrelations.
Note. Naturalness and tidiness are negatively correlated.

In addition to the above exploratory investigations, the thesis also conducted confirmatory investigations in which seven theory-based hypotheses related to preferences for sustainable design were examined in detail. The following sections summarise and discuss the results of the hypothesis testing.

The first hypothesis concerned the effects of information regarding sustainability on the evaluation of sustainability. It was hypothesised that providing specific information about the functions of sustainable design would change participants' evaluation of sustainability. The analyses found significant effects of specific information on the evaluation of sustainability. Specific information caused significantly higher evaluations in the case of sustainable design examples and significantly lower evaluations in the case of unsustainable design examples. The purpose of specific information was to help participants understand what design examples do and to alter their evaluation of sustainability. The findings confirm that specific information fulfills this purpose. General information about environmental problems, on the other hand, seems to have no effects on the evaluation of sustainability.

The second hypothesis involved the effects of information about sustainability on preference. It was hypothesised that information about sustainability would alter preferences for sustainable design. However, the effects of specific information on preference were limited. The effects of specific information on preference ranged from none (nonsignificant) to small depending on the types of design example. In the case of sustainable design examples, specific information has a significant but small effect on participants' preferences. In the case of the unsustainable design examples, specific information explaining negative environmental impacts inflicted by the examples does not seem to have any effects on preference. General information again has no effects on participants' preferences. The findings suggest that information is not entirely effective to change people's preferences for sustainable design.

Four hypotheses were tested in the examination of models of preferences for sustainable design. The results of the analyses supported the hypothesis that participants' evaluation of sustainability influences their preferences for sustainable design. The findings suggest that it is possible to alter people's preferences by changing their cognitive evaluation. However, the effect of evaluation on preference was not very extensive. The model explained only one third of the total variability of preference. The analyses of the model supported another hypothesis concerning the effect of environmental attitudes on preferences. The findings suggest a small but significant effect of environmental attitudes on preferences for sustainable design. However, the analyses were not able to detect a hypothesised effect of environmental knowledge on evaluation of sustainability. Examination of the model did find a very strong correlation between environmental knowledge and attitudes.

The final hypothesis examined in this study concerned cultural comparisons between Japanese and Australian participants. It was hypothesised that if cultural differences in preference exist, they may be due to differences in the evaluation of sustainability. The two cultural groups differed in their preferences for the unsustainable design examples. However, the analysis in this instance revealed that there was no significant cultural difference in the evaluation of sustainability. The findings suggest that the cultural difference in preference in this case involved factors other than the evaluation of sustainability.

It has to be emphasised that cultural comparisons between the two countries produced more similarities than differences. No cultural differences were found in preferences for sustainable design examples. The evaluation of sustainability also showed no cultural differences both in sustainable and unsustainable design examples. Correlations between the Japanese and Australian participants in terms of preference and evaluation of sustainability also revealed a very high degree of agreement between the two cultural groups.

Figure 55 summarises the results of the hypothesis testing portion of the study. In this diagram, a bold arrow indicates a significant effect from one variable to the other, and a bold double sided arrow means a significant correlation. A "thin" arrow indicates that a significant effect was found in some cases. A dotted line indicates that no effect was found between constructs. Out of the seven research hypotheses, this study rejected two hypotheses: one involving environmental knowledge and the other related to cultural comparisons. Five hypotheses were temporarily accepted in this thesis.

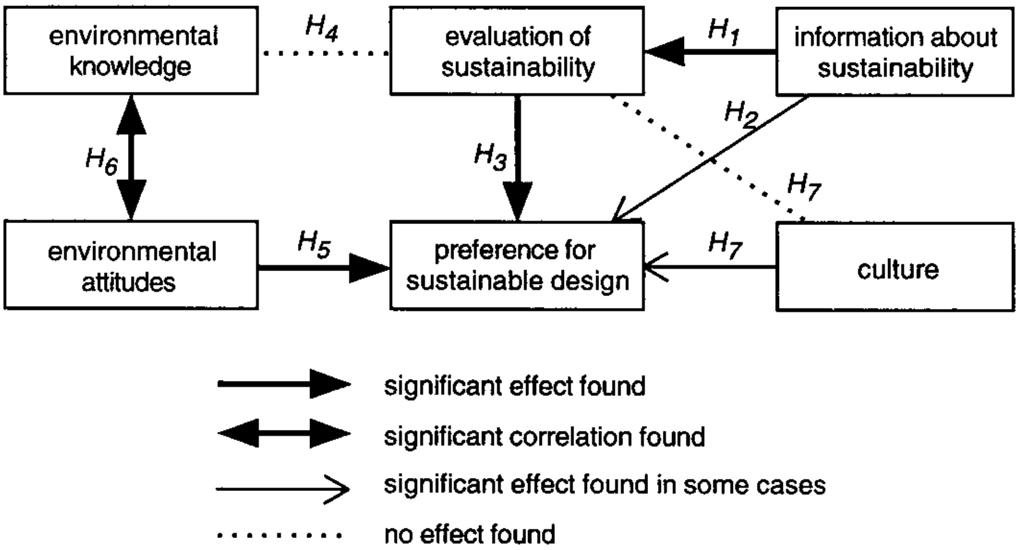


Figure 55. Results of the hypothesis testing in the research.
Note. The significant effect of H_1 was found in the case of specific information.

Implications of the Research Findings

The research findings provide some insights into the understanding of the perceptions of sustainable design. This section summarises the implications for theory and practice contained in the research findings.

The findings of this research suggest that people's perceptual evaluation of sustainability is an important criterion in their preferences for sustainable design. It can be argued that this relationship is based on participants' considerable concern toward the environment. Past studies on environmental attitudes have found that people are highly concerned with environmental problems (e.g., Dunlap et al., 1993; Scott & Willits, 1994). However, the findings also suggested that this concern is not the most influential motive of preferences for sustainable design. Preferences for culturally favoured images were high despite that their evaluation scores were low. This suggests that cultural values of people are a stronger determinant than the evaluation of sustainability in people's preference judgments.

Another implication of the study concerns the importance of visibility of sustainability in the perception of sustainable design. It can be inferred from the results that sustainable design may "exist," for lay observers, when evidence of its sustainability is visible. When a particular environment is visibly sustainable, people may see it as "sustainable design." In such an instance, people may consider its effect on the whole environment, and this broader consideration in turn may influence their preferences for sustainable design. However, when the design intention of sustainability is not visible, people may not realise that it is sustainable design. Thus, it is possible to argue that visibility provides observers a frame of reference in which the evaluation of sustainability becomes an important factor in their preference judgments. It is known that a different frame of reference or purpose of evaluation leads to different preference focuses (e.g., Hull & Revell, 1989; Purcell et al., 1994). Further investigation is necessary to further study the role of the visibility of sustainability and its relation to a frame of reference.

The findings also indicate that the effects of information on the evaluation of sustainability are very strong, but their effects on preference are more limited. Consideration from the perspective of affect and cognition may explain this situation. Zajonc and Markus (1982) have argued that preferences are phenomena primarily based on affect. Cognition provides initial justification for affective responses. However, affect can become independent of cognitive components in the course of time. Thus effectiveness of cognitive means of persuasion (information) on preference is influenced by the extent to which affect is separated from cognition. Due to a long period of exposure to a sociocultural milieu, preference for a particular object, which is originally learned, may be become affect-dominant. In such a case, preferences are relatively stable and not easily amenable to cognitive means of persuasion. The findings of the study as well as the above theory agree that providing information alone is not always an effective way to change people's preferences. To further alter preferences, affective means of persuasion would also need to be employed.

Causal effects of cognitive evaluation on preferences for sustainable design are supported by the research findings. The examination of the hypothetical models suggested that a change in people's evaluation of sustainability can lead to a change in their preferences for sustainable design. The results suggest that people's preferences for sustainable design are partly based on their evaluation of sustainability. However, the model also suggested that the effects of cognitive evaluation on preferences are moderate. This indicates that simply improving people's evaluation of sustainability has a limited effect in changing their preferences for sustainable design.

Theoretical contributions of this study need to be mentioned. The study aimed to expand the scope of environmental preference by incorporating a cognitive component, i.e., the evaluation of sustainability. A theoretical model integrating this component was proposed based on the conventional model of preference. The analyses found compelling evidence that suggests the involvement of cognitive evaluation in preferences for sustainable design. First, very high correlation coefficients between preference and cognitive evaluation were obtained. Second, the model predicting preference with evaluation of sustainability, environmental knowledge, and attitudes fit the data well and explained one third of the variance in preference. Influences of highly cognitive elements such as sustainability in environmental preference have not been heavily researched to date. The current study has shown empirically the role of cognition in preferences for sustainable design.

Figure 56 illustrates the findings of the research based on the expanded model of preference as shown in Figure 11 in Chapter 4. As the diagram suggests, preferences for sustainable design are significantly influenced by the evaluation of sustainability and environmental attitudes. Culture also has a significant influence on preference on limited occasions. Neither environmental knowledge nor culture has a significant effect on evaluation.

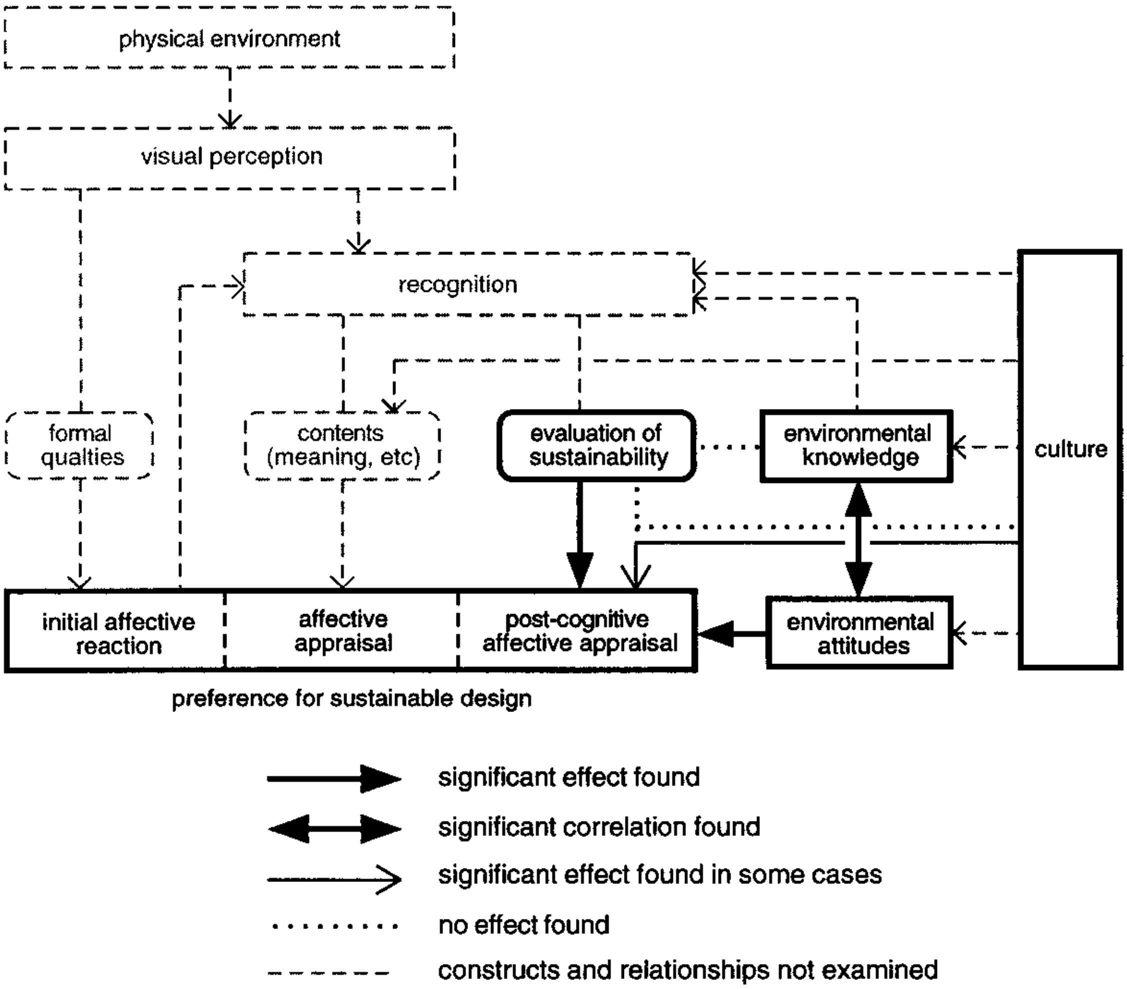


Figure 56. The expanded model of environmental preference showing the research findings.

Another contribution of this research is the development of an instrument to measure the perceptual degree of sustainability. The Perceptual Sustainability Evaluation scale was possibly the first attempt to measure people's perceptual evaluation of sustainability. Face validity of the scale was ascertained through interviews with experts. The analyses indicated that the scale has moderate reliability. For further and general use of the scale, more rigorous validity and reliability studies are necessary. However, it can be argued that the scale proposed in this thesis provides a starting point for the psychometric measurement of the evaluation of sustainability.

The analysis did not find a significant effect of environmental knowledge on evaluation of sustainability. This study measured people's knowledge about *general* environmental issues. The results imply that general environmental knowledge is not relevant to the evaluation of sustainable design. As discussed previously, knowledge about general issues is different from knowledge about specific strategies to solve those issues. It can be suggested from the results that as a predictor of people's evaluation of sustainability, *specific* knowledge about means to solve environmental problems is much more appropriate and effective.

The findings related to the influence of environmental attitudes on preference are also new in this field. Since environmental preference has been mostly applied to situations which do not explicitly involve environmental attitudes as a salient factor, the relationship between preference and attitudes has not been researched so far. Although the effect of attitudes on preference was not large, the results suggest another avenue of environmental preference research. The findings of the study also present a new possibility of altering people's preferences for sustainable design.

Recommendations Based on the Research Findings

Achieving sustainability is obviously an important and urgent task in our society. The planning, design, and construction of sustainable buildings, landscapes, and urban areas are all important to help promote sustainability in the environment. The fundamental proposition of this thesis is that improving people's preferences for sustainable design can contribute to enhancing sustainability in the environment. To achieve this goal, the thesis can offer some recommendations, based on the empirical findings, for design and management practices of sustainable design.

The findings suggest that people's evaluation of sustainability is highly correlated with their preference for sustainable design. What needs to be stressed in this context is that people's evaluation depends on whether sustainability of the design is visible or not. Even when a particular sustainable design happens to employ state-of-the art technologies to mitigate environmental problems, the findings of the study indicate that people's evaluation will be low if its sustainability is not visibly recognisable. This seemingly self-evident statement is important because some designers tend to think that the value of sustainability will speak for itself (Mozingo, 1997). It needs to be reminded that the "visible" sustainable design examples such as the windmill were as preferred as the culturally favoured design examples including the suburban house and park. Thus, the findings of this study strongly suggest that architects and other environmental designers pay close attention to the visual aspect of sustainable design so that it communicates its functions and intentions to people.

Another recommendation of the study relates to the importance of tidiness and care in the perception of sustainable design. Sustainable design often employs natural elements. The research findings indicate that people tend to judge natural elements as contributing to sustainability, but at the same time tend to consider them untidy. The current study, as well as the study by Nassauer (1993), demonstrates that tidy appearance and evidence of human care are associated with preference. Thus, in the design, construction, and management process of sustainable design, it is important that decisions are made taking perception of tidiness and human care into consideration.

The findings repeatedly revealed the importance of cultural values of people in preference judgments. This factor turned out to be very strong in its influence on preferences. Cultural factors cannot be ignored in the promotion of sustainable design. However, it appears that the vocabulary of sustainable design and that of culturally favoured design do not have much in common (Rapoport, 1994). To fill the gap, designers and researchers, mainly involved in landscape architecture, have been advocating the integration of sustainability and aesthetic values (e.g., Eaton, 1990; Gobster, 1999; Nassauer, 1997; Thayer, 1994). However, the exploration is still on its way. Further empirical research and design attempts will be necessary to merge the two values in sustainable design.

People's preferences for sustainable design can be altered by ways other than design interventions. The findings suggest that information explaining what a particular sustainable design does to improve the quality of the environment influences people's evaluation and consequently their preferences to some degree. In a metaphorical sense, such information serves to increase the visibility of sustainability. Information can be conveyed in many forms: notice boards, newsletters, communication among neighbours, organised tours, and public lectures to name a few. However, it should be remembered that the effects of information on preference can be limited. The analyses found that only a moderate degree of change in preference occurs as a result of a change in evaluation. It is also important to notice that information needs to be specific in discussing functions and the effectiveness of sustainable design. General information addressing large scale environmental issues and slogans is likely to have little effects on evaluation of and preferences for sustainable design.

Based on the results of the study, recommendations for design and management of sustainable design can be summarised as follows. Preferences for sustainable design may be enhanced indirectly (1) by improving its visibility of sustainability, and directly (2) by making it tidy and showing signs of active human care and maintenance, and (3) by incorporating cultural aspiration into sustainable design. Additionally, to help people appreciate sustainable design, it is also recommended that various forms of specific information be spread to attract people's attention and maintain their interest.

Limitations of the Study

One of the most obvious limitations of the research was the number of stimuli employed to elicit responses from the participants. Eleven design examples were employed among which two were examples of culturally favoured but unsustainable design. Since sustainable design targets various environmental problems and engages many measures to achieve sustainability, the range of sustainable design can be quite broad. In this sense, it is difficult to say that the design examples represented the complete breadth and all types of sustainable design. Further research with more design examples will be necessary in this regard to broaden the generalisability of findings.

Another shortcoming of the study was the selection of respondents. Because of the use of experimental design, which allows the inference of causality, undergraduate students were chosen as participants in the data collection process. Although students from various fields were asked to participate in the research, it is difficult to know to what degree responses from the participants represented those of the wider public. Especially, environmental knowledge and attitudes of the chosen participants were considered to be different from those of general public. In addition, due to a classroom situation in which data were collected, participants may have felt that they needed to be "politically correct" in their responses to the questions. Since the questionnaire was administered in a group situation, where participants were told that their identity would not be disclosed, it seems unlikely that they felt obliged to answer in a politically correct manner. However, a classroom setting may have influenced participants' responses. Further generalisation of the findings would be assisted by a follow-up study with a broader sample in different settings.

The use of photographs as stimuli may have imposed some restriction. The validity and reliability of the use of photographs were discussed in Chapter 5. Although the literature supports the use of photographs as a reliable and valid surrogate of the environment, the way the design examples were "framed" in photographs may have influenced people's evaluation of them. Sustainability of one area is interrelated to other areas in a complex manner. For instance, the construction of a building in an urban area is likely to have effects on sustainability of nearby and possibly remote rural areas. Thus, identification of a degree of sustainability always involves a problem of the *boundary* within which sustainability is assessed (Bell & Morse, 1999). Framing the design examples in photographs may have suggested implicitly a boundary to be considered for evaluation of sustainability. Namely, in evaluating sustainability, some participants might have neglected the complex relationships between a design example and the environment outside of the photograph.

Another related concern about the use of photographs is that presenting design examples in photographs may have predisposed a respondent to be a "distant observer" rather than an active participant of the environment. In the case of scenic landscape evaluation in which spectators observe a scene from a distance, this may not pose a serious problem. However, as Berleant (1988) implied, the mode of appreciation in sustainable design needs to be not contemplative but participatory. Photographic presentation might have provided a frame of reference that implicitly suggests "distance" between respondents and an object in the photograph. These limitations with respect to the use of photographs would have been less explicit, if participants evaluated the design examples on-site.

In the examination of the hypothetical models of preferences for sustainable design, the scales of environmental knowledge and attitudes turned out to measure the same construct. Because of this redundancy, it was not able to investigate separate effects of environmental knowledge versus attitudes on evaluation and preference. In addition, the findings suggested that knowledge about specific strategies to solve environmental problems is more relevant to evaluation of sustainability than knowledge about general environmental issues. Different scales of environmental knowledge and attitudes will be necessary in future study to investigate in what way environmental knowledge and attitudes mediate the relationship between preference and evaluation.

Future Research Directions

This study was based on a working hypothesis that preferred sustainable design is more acceptable to the public, thus enhancing sustainability in the environment. Although the literature supports this hypothesis from a theoretical point of view, it has not previously been examined empirically. In future, this hypothesis needs to be tested. Future research can examine the construct of *acceptance* by various parties involved in the selection, construction, and maintenance of sustainable design. Alternatively, research can also investigate people's behaviours relevant to preferred (and possibly unpreferred) sustainable design.

It was mentioned in Chapter 4 that the study belongs to "cognitive" paradigm. Namely, the study was interested in people's reactions (preferences and evaluation) to various types of sustainable design. Future research may involve a "psychophysical" study in which the relationship between physical attributes of sustainable design and people's perception is investigated. This type of study may be able to inform designers and planners of important design criteria that influence the way people feel and think about sustainable design. For instance, the "visibility" of sustainability was identified as a salient factor affecting people's perception of sustainable design. A psychophysical study can explore this issue further and may provide information as to possible environmental cues that influence the visibility.

The data employed in the present study was quantitative. In the future, a study based on qualitative data may be conducted to further investigate people's perception of sustainable design. Qualitative data, which may be collected from interviews and discussions, will be quite helpful to have a deeper understanding as to the way people perceive sustainable design. Research involving qualitative data may reinforce the results obtained in this study.

In this research, two types of information were given to the participants and their effects were examined. It was found that this cognitive means of persuasion produced at most a limited effect on preferences for sustainable design. It seems worthwhile in future to investigate the effects of different types of persuasion methods such as affective means or a mixture of affective/cognitive means. To this end, it is necessary to develop affective or affective/cognitive means of persuasion. As an affective persuasion, *fear* of environmental destruction may be employed. In the area of risk management, fear is considered to have some effects on people's "preparedness" to some natural disasters (e.g., Rustemli & Karanci, 1999). Beauty and joy associated with sustainable design may also be emphasised and conveyed to people as affective persuasion. A cognitive/affective means of persuasion can include a video presentation that contains both emotional and instructive contents. There will be a number of ways of persuasion other than the above. Findings as to effective types of persuasion will contribute not only insights into a better understanding of preferences for sustainable design but also recommendations to management practices, environmental education, and environmental policy concerning sustainability.

The current study employed undergraduate university students as participants. In the future, it would be interesting to investigate perception of sustainable design by those who are involved in the construction of sustainable design. They include architects, landscape architects, planners, park and forest managers, ecologists, developers, and policy makers. There are several merits in this investigation. First, by using a panel of experts who have enough knowledge to assess a degree of sustainability, it is possible to obtain a score that approximates an actual degree of sustainability of a certain sustainable design. Comparison of this score with a score by a lay parson may tell how well the person knows about the design. Second, the inclusion of experts who are supposed to have more knowledge about sustainable design may result in a sample that has a larger variability in respondents' knowledge. This may allow researchers to examine the role of knowledge in preferences for sustainable design more precisely. Third, it is possible to compare preference for sustainable design between lay people and the professional. It is expected that experts and the lay public are different in perception and appreciation of sustainable design due to a highly specialized training for the experts (e.g., Hershberger, 1988). The comparisons have been conducted before in several fields of visual resource management but not in the area of sustainable design. It can be argued that the problems of sustainable design discussed in this thesis have originated from different expectations for sustainable design between designers and users of sustainable design. In this sense, identifying the differences between the two parties and informing the difference to the professional are worthwhile to make them aware of the perceptual discrepancy between their preferences and those of the public for whom they design.

Future research of preferences for sustainable design involving more sustainable design examples is also recommended. As discussed previously, there are many different types sustainable design applied to different situations. The findings of the research such as the effects of cognitive evaluation on preference will be reinforced if the same results are replicated with a different set of design examples. The pilot study of the research found that the bike path is different from the rest of the design examples in that its sustainability is dependent not on the designed environment itself but on behaviours of people who use the environment. It is worthwhile to investigate people's perception of this type of sustainable design. The research including sustainable design examples such as the bike path may need to involve people's behaviour in addition to their perception.

It may be also worthwhile to experiment with different ways of presenting design examples. It may be possible that a different set of photographs may elicit different responses. It is argued in this chapter that framing of sustainable design may have influenced participants' preferences and evaluation of sustainability. However, as the pilot study indicated, participants may have responded not just to the "image" but to the "title" of examples. In this sense, it is not yet known exactly to what degree different photographs lead to different evaluation. To investigate this issue, alternative ways of presentation such as computer simulation and video imaging could be used to avoid the effect of "framing." The influence of framing may be less obvious in images provided in these ways of presentation. In addition, on-site evaluation could be compared with conventional photographic evaluation to further validate the findings of the study.

The study employed structural equation modeling (SEM) to examine the relationships between evaluation of sustainability and preferences for sustainable design. Due to the relatively small sample size (217 cases), the SEM analysis was not able to take the experimental conditions into consideration. However, by expanding sample size, it is possible to investigate whether the effects of cognitive evaluation on preference differ between those who learned in what way the sustainable design examples work and those who did not. Similarly, if the two cultural groups are large enough, it is also possible to investigate the differences in the model of preferences for sustainable design between different cultures. SEM is a versatile statistical technique to examine hypothetical relationships between latent constructs. Application of SEM in future research not just in this particular topic but also in other topics in EBS is expected to provide richer insights into the interaction between people and the environment.

To make the condition between the control and treatment groups equal, the participants were informed that they would be evaluating images related to environmental problems. Although this was necessary, it may have provided a strong frame of reference when they were assessing the photographs. The results of the study indicate that some of the sustainable design examples were as preferred as culturally favoured design examples. It is possible to consider that this is because of the initial statement that highlighted an environmental point of view. In future, it seems worthwhile to measure the effect of this frame of reference on preferences for and evaluation of sustainable design.

Another future research topic with respect to the frame of reference is to explore whether "visibility" of sustainability can provide a particular frame of reference to observers. Earlier in this chapter, it was considered that people may focus on different salient characteristics depending on the visibility of sustainability of the environment. Empirical research of this issue is needed to further explore the role of visibility of sustainability in people's preferences for sustainable design.

The scale to measure the perceived degree of sustainability was proposed in the study. A more valid and reliable measure of this construct needs to be developed in the future. Since the study was interested in people's perceptions of sustainable design, the scale measuring a perceived degree of sustainability was suffice. However, from an environmental assessment point of view, a comprehensive scale measuring not just perceptual but also physical degree of sustainability may be required (Daniel, 2001). As the results suggest, due to lack of proper knowledge, lay people's evaluation of sustainable design does not necessarily reflect the actual degree of sustainability. In this sense, correct measurement of a physical degree of sustainability needs to be done by expert assessment. By combining the two scales, i.e., a scale using public perception to measure the sociocultural aspects of sustainable design and that of expert assessment to measure its biophysical aspects, it is possible to obtain a holistic scale measuring the overall sustainability of the environment.

Finally, environmental preference and the Perceptual Sustainability Evaluation scale can be employed to test sustainable design and management practices that consider not only the physical aspects of the environment but also its sociocultural aspects. Although such attempts of sustainable design are still rare, it is interesting and important to investigate the effects of design and management efforts that intend to enhance the sociocultural aspect of sustainable design. Accumulation of and the feedback from this type of empirical research are essential to achieve sustainable designs that are sustainable not only in a physical and biological sense but also in a sociocultural sense.

REFERENCES

Adams, C., & Elizabeth, L. (Eds.). (2000). *Alternative construction: Contemporary natural building methods*. New York: Wiley.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Alario, M. (2000). Urban and ecological planning in Chicago: Science, policy and dissent. *Journal of Environmental Planning and Management, 43*(4), 489-504.

Aldenderfer, M. S., & Blashfield, R. K. (1984). *Cluster analysis*. Beverly Hills, CA: Sage.

Alhakami, A. S., & Slovic, P. (1994). A psychological study of the inverse relationship between perceived risk and perceived benefit. *Risk Analysis, 14*(6), 1085-1096.

Altman, I., Rapoport, A., & Wohlwill, J. F. (Eds.). (1980). *Human behavior and environment: Advances in theory and research: Vol. 4. Environment and culture*. New York: Plenum Press.

Anderson, L. M., Mulligan, B. E., Goodman, L. S., & Regen, H. Z. (1983). Effects of sounds on preferences for outdoor settings. *Environment and Behavior, 15*, 539-566.

Anink, D., Boonstra, C., & Mak, J. (1996). *Handbook of sustainable building: An environmental preference method for selection of materials for use in construction and refurbishment*. London: James & James.

Appleton, J. (1975). *The experience of landscape*. London: Wiley.

Appleyard, D. (1969). Why buildings are known. *Environment and Behavior, 1*(2), 131-156.

Appleyard, D. (1979). The environment as a social symbol: Within a theory of environmental action and perception. *Journal of the American Planning Association, 45*, 143-153.

Arbuckle, J. L. (1997). *AMOS user's guide: Version 3.6*. Chicago: SPSS.

Arcury, T. A. (1990). Environmental attitude and environmental knowledge. *Human Organization, 49*(4), 300-304.

Arcury, T. A., & Christianson, E. H. (1990). Environmental worldview in response to environmental problems: Kentucky 1984 and 1988 compared. *Environment and Behavior,* *22*(3), 387-407.

Arcury, T. A., & Johnson, T. P. (1987). Public environmental knowledge: A statewide survey. *Journal of Environmental Education, 18*(4), 31-37.

Arcury, T. A., Johnson, T. P., & Scollay, S. J. (1986). Ecological worldview and environmental knowledge: The "New Environmental Paradigm." *Journal of Environmental Education, 17*(4), 35-40.

Ataov, A. (1998). Environmental aesthetics. *Journal of Planning Literature, 13*(2), 239-257.

Balling, J. D., & Falk, J. H. (1982). Development of visual preference for natural environments. *Environment and Behavior, 14*(1), 5-28.

Bartlett, A. A. (1997). Reflections on sustainability, population growth, and the environment—revisited. *Renewable Resources Journal, 15*(4), 6-23.

Bechtel, R. B., Verdugo, V. C., & Pinheiro, J. Q. (1999). Environmental belief systems: United States, Brazil, and Mexico. *Journal of Cross-Cultural Psychology, 30*(1), 122-128.

Beder, S. (1996). *The nature of sustainable development* (2nd ed.). Newham, VIC, Australia: Scribe.

Bell, S., & Morse, S. (1999). *Sustainability indicators: Measuring the immeasurable?* London: Earthscan.

Bentler, P. M., & Chou, C.-P. (1987). Practical issues in structural modeling. *Sociological Methods and Research, 16*, 78-117.

Berkes, F., & Folke, C. (1998). Linking social and ecological systems for resilience and sustainability. In F. Berkes, C. Folke, & J. Colding (Eds.), *Linking social and ecological systems: Management practices and social mechanisms for building resilience*. New York: Cambridge University Press.

Berleant, A. (1988). Aesthetic perception in environmental design. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications*. New York: Cambridge University Press.

Berlyne, D. E. (1971). *Aesthetics and psychobiology.* New York: Appleton.

Biddulph, M. J. (1995). The value of manipulated meanings in urban design and architecture.

Environment and Planning B: Planning and Design, 22, 739-762.

Bonta, J. (1980). Notes for a theory of meaning in design. In G. Broadbent, R. Bunt, & C. Jencks (Eds.), *Sings, symbols, and architecture*. Chichester, England: Wiley.

Boulding, K. E. (1956). *The image*. Ann Arbor, MI: University of Michigan Press.

Bourassa, S. (1990). A paradigm for landscape aesthetics. *Environment and Behavior, 22*(6), 787-812.

Bradley, J. C, Waliczek, T. M., & Zajicek, J. M. (1999). Relationship between environmental knowledge and environmental attitude of high school students. *Journal of Environmental Education, 30*(3), 17-21.

Bratt, C. (1999). The impact of norms and assumed consequences on recycling behavior. *Environment and Behavior, 31*(5), 630-656.

Briffet, C. (2001). Sustaining interactions between the natural and built environment in Singapore. *Architectural Design, 71*(4), 62-67.

Broadbent, G. (1980). General introduction. In G. Broadbent, R. Bunt, & C. Jencks (Eds.), *Sings, symbols, and architecture*. Chichester, England: Wiley.

Brown, L. R., Flavin, C., & Kane, H. (1996). *Vital signs 1996: The trends that are shaping our future*. New York: W. W. Norton.

Brown, L. R., Starke, L., Renner, M., & Halweil, B. (2000). *Vital signs 2000-2001: The environmental trends that are shaping our future*. London: Earthscan.

Brunson, M. W. (1993). "Socially acceptable" forestry: What does it imply for ecosystem management? *Western Journal of Applied Forestry, 8*(4), 116-119.

Brunson, M. W., & Reiter, D. K. (1996). Effects of ecological information on judgments about scenic impacts of timber harvest. *Journal of Environmental Management, 46*(1), 31-41.

Buhyoff, G. J., Leuschner, W. A., & Wellman, J. D. (1979). Aesthetic impacts of southern pine beetle damage. *Journal of Environmental Management, 8*(3), 261-267.

Buhyoff, G. J., Wellman, J. D., Koch, N. E., Gauthier, L., & Hultman, S. (1983). Landscape preference metrics: An international comparison. *Journal of Environmental Manage-*

ment, 16, 181-190.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Dallas, TX: Houghton Mifflin.

Carlson, A. (1979). Appreciation and the natural environment. *Journal of Aesthetics and Art Criticism, 37*(3), 267-275.

Carlson, A. (1995). Nature, aesthetic appreciation, and knowledge. *Journal of Aesthetics and Art Criticism, 53*(4), 393-400.

Carlson, A. (2000). *Aesthetics and the environment: The appreciation of nature, art and architecture*. London: Routledge.

Carson, R. (1963). *Silent spring*. London: Hamish Hamilton.

Chenoweth, R. E., & Gobster, P. H. (1990). The nature and ecology of aesthetic experiences in the landscape. *Landscape Journal, 9*(1), 1-8.

Clark, M. E. (1994). Integrating human needs into our vision of sustainability. *Futures, 26*(2), 180-184.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Earlbaum.

Collier, T. (Ed.). (1995). *Design, technology and the development process in the built environment*. London: E & Fn Spon.

Commoner, B. (1971). *The closing circle: Nature, man, and technology*. New York: Knopf.

Corson, W. H. (1994). Changing course: An outline of strategies for a sustainable future. *Futures, 26*(2), 206-223.

Crosbie, M. J. (1994). *Green architecture: A guide to sustainable design*. Rockport, MA: Rockport.

Daily, G. C., & Ehrlich, P. R. (1992). Population, sustainability, and earth's carrying capacity. *BioScience, 42*(10), 761-772.

Daly, H. E., & Cobb, J. B., Jr. (1994). *For the common good: Redirecting the economy toward community, the environment, and a sustainable future* (2nd ed.). Boston: Beacon Press.

Daniel, T. C. (2001). Whither scenic beauty? Visual landscape quality assessment in the 21st century. *Landscape and Urban Planning 54*, 267-281.

Dawes, R. M., & Smith, T. L. (1985). Attitude and opinion measurement. In O. Lindzey & E. Aronson (Eds.), *Handbook of social psychology*. New York: Random House.

Dearden, P. (1981). Consensus and the landscape quality continuum: A research note. *Landscape Research, 6*, 31.

Devlin, A. S., & Bernstein, J. (1995). Interactive wayfinding: Use of cues by men and women. *Journal of Environmental Psychology, 15*(1), 23-38.

Devlin, K., & Nasar, J. L. (1989) The beauty and the beast: Some preliminary comparisons of 'high' versus 'popular' residential architecture and public versus architect judgments of same. *Journal of Environmental Psychology, 9*, 333-344.

De Young, R. (1993). Changing behavior and making it stick: The conceptualization and management of conservation behavior. *Environment and Behavior, 25*(4), 485-505.

Diesendorf, M., & Hamilton, C. (Eds.). (1997). *Human ecology, human economy*. St Leonards, NSW, Australia: Allen & Unwin.

Downs, R. M., & Stea, D. (1973). Cognitive maps and spatial behavior: Process and products. In R. M. Downs & D. Stea (Eds.), *Image and environment: Cognitive mapping and spatial behavior*. Chicago: Aldine.

Dubos, R. J. (1980). *The wooing of earth*. New York: Scribner.

Dunlap, R. E., Gallup, G. H., Jr., & Gallup, A. M. (1993). Of global concern: Results of the health of the planet survey. *Environment, 35*(9), 6-15, 33-39.

Dunlap, R. E., & Van Liere, K. D. (1978). The "New Environmental Paradigm": A proposed measuring instrument and preliminary results. *Journal of Environmental Education, 9*(4), 10-19.

Dwyer, W. O., Leeming, F. C., Cobern, M. K., Porter, B. E., & Jackson, J. M. (1993). Critical review of behavioral interventions to preserve the environment: Research since 1980. *Environment and Behavior, 25*(3), 275-321.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. San Diego, CA: Harcourt

Brace Jovanovich.

Eaton, M. M. (1990). Responding to the call for new landscape metaphors. *Landscape Journal, 9*(1), 22-27.

Eaton, M. M. (1997). The beauty that requires health. In J. I. Nassauer (Ed.), *Placing nature: Culture and landscape ecology*. Washington, DC: Island Press.

Edwards, B. (Ed.). (2001). *Green Architecture. Architectural Design, 71*(4).

Edwards, K. (1990). The interplay of affect and cognition in attitude formation and change. *Journal of Personality and Social Psychology, 59*(2), 202-216.

Ehrlich, P. R., & Ehrlich, A. H. (1990). *The population explosion*. New York: Simon and Schuster.

Environment Australia (1998). *Techniques for reducing construction waste: Handbook*. Canberra, Australia: Commonwealth Department of the Environment.

Evans, G. W., & Cohen, S. (1987). Environmental stress. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology: Vol. 1*. New York: Wiley.

Farrell, A., & Hart, M. (1998). What does sustainability really mean? The search for useful indicators. *Environment, 40*(9), 4-15.

Fenton, D. M., & Reser, J. P. (1988). The assessment of landscape quality: An integrative approach. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications*. New York: Cambridge University Press.

Flannery, T. F. (1994). *The future eaters: An ecological history of Australasian lands and people*. Chatswood, NSW, Australia: Reed Books.

Fransson, N., & Gärling, T. (1999). Environmental concern: Conceptual definitions, measurement methods, and research findings. *Journal of Environmental Psychology, 19*, 369-382.

French, H. F. (1997). Learning from the ozone experience. In L. R. Brown & Worldwatch Institute. (Eds.), *State of the world 1997: A Worldwatch Institute report on progress towards a sustainable society*. London: Earthscan.

Galatowitsch, S. M. (1998). Ecological design for environmental problem solving. *Land-*

scape Journal, Special Issue, 99-107.

Gardner, G. T., & Stern, P. C. (1996). *Environmental problems and human behavior.* Boston: Allyn and Bacon.

Gaver, W. W., & Mandler, G. (1987). Play it again, Sam: On liking music. *Cognition and Emotion, 1*, 259-282.

Geller, E. S. (1992). Solving environmental problems: A behavior change perspective. In S. Staub & P. Green (Eds.), *Psychology and social responsibility: Facing global challenges*. New York: New York University Press.

Geller, J., & Lasley, P. (1985). The New Environmental Paradigm scale: A reexamination. *Journal of Environmental Education, 17*(1), 9-12.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Gifford, R., & Ng, C. F. (1982). The relative contribution of visual and auditory cues to environmental perception. *Journal of Environmental Psychology, 2*, 275-284.

Gigliotti, L. M. (1990). Environmental education: What went wrong? What can be done? *Journal of Environmental Education, 22*(1), 9-12.

Gimblett, H. R. (1990). Environmental cognition: The prediction of preference in rural Indiana. *Journal of Architectural and Planning Research, 7*(3), 222-234.

Gipe, P. (1995). *Wind energy comes of age*. New York: Wiley.

Girardet, H., Dunster, B., & Johnston, L. (2001). Eco urbanism. *AR Australia,* No. 77, 74-79.

Glass, D. C., Singer, J. E., & Pennebaker, J. W. (1977). Behavioral and physiological effects of uncontrollable environmental events. In D. Stokols (Ed.), *Perspectives on environment and behavior: Theory, research, and applications*. New York: Plenum Press.

Gobster, P. H. (1994). The urban savanna: Reuniting ecological preference and function. *Restoration and Management Notes, 12*(1), 64-71.

Gobster, P. H. (1999). An ecological aesthetic for forest landscape management. *Landscape Journal, 18*, 54-64.

Gobster, P. H., & Chenoweth, R. E. (1989). The dimensions of aesthetic preference: A quantitative analysis. *Journal of Environmental Management, 29*(1), 47-72.

Golley, F. B., & Bellot, J. (1991). Interactions of landscape ecology, planning and design. *Landscape and Urban Planning, 21*(1), 3-11.

Gómez-Limón, J., & de Lucío, J. V. (1999). Changes in use and landscape preferences on the agricultural-livestock landscapes of the central Iberian Peninsula (Madrid, Spain). *Landscape and Urban Planning, 44*, 165-175.

Gonzalez, R. A. (1998). Blueprint for a sustainable Bay Area. *Place, 12*(1), 32-37.

Goodland, R. (1995). The concept of environmental sustainability. *Annual Review of Ecology and Systematics, 26*, 1-24.

Gorham, E. (1997). Human impacts on ecosystems and landscapes. In J. I. Nassauer (Ed.), *Placing nature: Culture and landscape ecology*. Washington, DC: Island Press.

Goudie, A. (2000). *The human impact on the natural environment* (5th ed.). Cambridge, MA: MIT Press.

Graham, N. E. (1995). Simulation of recent global temperature trends. *Science*, 267, 666-671.

Grant, J., Manuel, P., & Joudrey, D. (1996). A framework for planning sustainable residential landscapes. *Journal of the American Planning Association, 62*(3), 331-344.

Hagerhall, C. M. (2000). Clustering predictors of landscape preference in the traditional Swedish cultural landscape: Prospect-refuge, mystery, age and management. *Journal of Environmental Psychology, 20*(1), 83-90.

Hagerhall, C. M. (2001). Consensus in landscape preference judgements. *Journal of Environmental Psychology, 21(1), 83-92.*

Hair, J. F., Jr., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis with readings* (4th ed.). Upper Saddle River, NJ: Prentice Hall.

Hall, D. L. (1991). Landscape planning: Functionalism as a motivating concept from landscape ecology and human ecology. *Landscape and Urban Planning, 21*(1), 13-19.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243-1248.

Harte, M. J. (1995). Ecology, sustainability, and environment as capital. *Ecological Economics, 15*, 157-164.

Hartig, T., Mang, M., & Evans, G. W. (1991). Restorative effects of natural environment experiences. *Environment and Behavior, 23*(1), 3-26.

Hashimoto, A. (2000). Environmental perception and sense of responsibility of the tourism industry in Mainland China, Taiwan and Japan. *Journal of Sustainable Tourism, 8*(2), 131-146.

Hausbeck, K. W., Milbrath, L. W., & Enright, S. M. (1992). Environmental knowledge, awareness and concern among 11th-grade students: New York State. *Journal of Environmental Education, 24*(1), 27-34.

Healy, S. A. (1995). Science, technology and future sustainability. *Futures, 27*(6), 611-625.

Heath, T. (1988). Behavioral and perceptual aspects of the aesthetics of urban environments. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications.* New York: Cambridge University Press.

Heft, H. (1997). The relevance of Gibson's ecological approach to perception for environment-behavior studies. In G. T. Moore & R. W. Marans (Eds.), *Advances in environment, behavior, and design: Vol 4.* New York: Plenum Press.

Hempel, L. (1999). Conceptual and analytical challenges in building sustainable communities. In D. A. Mazmanian & M. E. Kraft (Eds.), *Toward sustainable communities: Transition and transformations in environmental policy.* Cambridge, MA: MIT Press.

Hershberger, R. G. (1988). A study of meaning and architecture. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications.* New York: Cambridge University Press.

Hersperger, A. M. (1994). Landscape ecology and its potential application to planning. *Journal of Planning Literature, 9*(1), 14-29.

Herzog, T. R. (1984). A cognitive analysis of preference for field-and-forest environments. *Landscape Research, 9*(1), 10-16.

Herzog, T. R. (1989). A cognitive analysis of preference for urban nature. *Journal of Environmental Psychology, 9*(1), 27-43.

Herzog, T. R., & Barnes, G. J. (1999). Tranquility and preference revisited. *Journal of Envi-*

ronmental Psychology, 19(2), 171-181.

Herzog, T. R., & Bosley, P. J. (1992). Tranquility and preference as affective qualities of natural environments. *Journal of Environmental Psychology, 12*(2), 115-127.

Herzog, T. R., Herbert, E. J., Kaplan, R., & Crooks, C. L. (2000). Cultural and developmental comparisons of landscape perceptions and preferences. *Environment and Behavior, 32*(3), 323-346.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986/87). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education, 18*(2), 1-8.

Hodgson, R. W., & Thayer, R. L., Jr. (1980). Implied human influence reduces landscape beauty. *Landscape Planning, 7*, 171-179.

Hough, M. (1995). *Cities and natural process*. New York: Routledge.

Howett, C. (1987). Systems, signs, sensibilities: Sources for a new landscape aesthetic. *Landscape Journal, 6*(1), 1-12.

Hu, L.-T., & Bentler, P. M. (1995). Evaluating model fit. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications*. Thousand Oaks, CA: Sage.

Hu, L.-T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*, 1-55.

Huck, S. W. (2000). *Reading statistics and research* (3rd ed.). New York: Longman.

Hudspeth, T. R. (1986). Visual preference as a tool for facilitating citizen participation in urban waterfront revitalization. *Journal of Environmental Management, 23*(4), 373-385.

Hull, R. B., IV, & Harvey, A. (1989). Explaining the emotion people experience in suburban parks. *Environment and Behavior, 21*(3), 323-345.

Hull, R. B., IV, & Revell, G. R. (1989). Cross-cultural comparison of landscape scenic beauty evaluations: A case study in Bali. *Journal of Environmental Psychology, 9*(3), 177-191.

Hull, R. B., IV, & Stewart, W. P. (1992). Validity of photo-based scenic beauty judgments.

Journal of Environmental Psychology, 12, 101-114.

Intergovernmental Panel on Climate Change. (1997). *Climate change 1995: The science of climate change*. New York: Cambridge University Press.

Ittelson, W. H. (1978). Environmental perception and urban experience. *Environment and Behavior, 10*(2), 193-213.

Jaccard, J., & Becker, M. A. (1997). *Statistics for the behavioral sciences* (3rd ed.). Pacific Grove, CA: Brooks/Cole.

Jackson, T., & Marks, N. (1999). Consumption, sustainable welfare and human needs—with reference to UK expenditure patterns between 1954 and 1994. *Ecological Economics. 28*(3), 421-441.

Jacobs, M. (1991). *The green economy*. London: Pluto Press.

Jepson, E. J., Jr. (2001). Sustainability and planning: Diverse concepts and close associations. *Journal of Planning Literature, 15*(4), 499-510.

John, D. (1994). *Civic environmentalism: Alternatives to regulation in states and communities*. Washington, DC: CQ Press.

Johnson, H. D. (1995). *Green plans: Greenprint for sustainability*. Lincoln, NE: University of Nebraska Press.

Judd, C. M., Smith, E. R., & Kidder, L. H. (1991). *Research methods in social relations* (6th ed.). Fort Worth, TX: Harcourt Brace Jovanovich.

Jussaume, R. A., & Higgins, L. (1998). Attitudes towards food safety and the environment: A comparison of consumers in Japan and the US. *Rural Sociology, 63*(3), 394-411.

Kaiser, F. G., & Shimoda, T. A. (1999). Responsibility as a predictor of ecological behaviour. *Journal of Environmental Psychology, 19*(3), 243-253.

Kaiser, F. G., Wölfing, S., & Fuhrer, U. (1999). Environmental attitude and ecological behaviour. *Journal of Environmental Psychology, 19*(1), 1-19.

Kaplan, R. (1983). The role of nature in the urban context. In I. Altman & J. F. Wohlwill, (Eds.), *Human behavior and environment: Vol. 6. Behavior and the natural environment*. New York: Plenum Press.

Kaplan, R. (2001). The nature of the view from home: Psychological benefits. *Environment and Behavior, 33*(4), 507-542.

Kaplan, R., & Herbert, E. J. (1988). Familiarity and preference: A cross-cultural analysis. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications*. New York: Cambridge University Press.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. New York: Cambridge University Press.

Kaplan, R. M., & Saccuzzo, D. P. (1997). *Psychological testing: Principles, applications, and issues* (4th ed.). Pacific Grove, CA: Brooks/Cole.

Kaplan, S. (1987). Aesthetics, affect, and cognition: Environmental preference from an evolutionary perspective. *Environment and Behavior, 19*(1), 3-32.

Kaplan, S. (1988a). Perception and landscape: Conceptions and misconceptions. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications*. New York: Cambridge University Press.

Kaplan, S. (1988b). Where cognition and affect meet: A theoretical analysis of preference. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications*. New York: Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*, 169-182.

Kaplan, S., & Kaplan, R. (1982a). *Cognition and environment: Functioning in an uncertain world*. New York: Praeger.

Kaplan, S., & Kaplan, R. (Eds.). (1982b). *Humanscape: Environments for people*. Ann Arbor, MI: Ulrich's Books.

Kaplan, S., & Kaplan, R. (1989). The visual environment: Public participation in design and planning. *Journal of Social Issues, 45*(1), 59-86.

Kapper, T., & Chenoweth, R. (2000). Landscape architecture and societal values: Evidence from the literature. *Landscape Journal, 19*, 149-155.

Kates, R. W. (2000). Population and consumption: What we know, what we need to know.

Environment, 42(3), 10-19.

Kates, R. W., Turner, B. L., & Clark, W. C. (1990). The great transformation. In B. L. Turner (Ed.), *The earth as transformed by human action: Global and regional changes in the biosphere over the past 300 years*. New York: Cambridge University Press with Clark University.

Kay, J. J., & Schneider, E. (1994). Embracing complexity: The challenge of the ecosystem approach. *Alternatives, 20*(3), 32-39.

Kellert, S. R. (1999). Ecological challenge, human values of nature, and sustainability in the built environment. In C. J. Kibert (Ed.), *Reshaping the built environment: Ecology, ethics, and economics*. Washington, DC: Island Press.

Kellomäki, S., & Savolainen, R. (1984). The scenic value of the forest landscape as assessed in the field and the laboratory. *Landscape Planning, 11*, 97-107.

Kibert, C. J. (1999). The promises and limits of sustainability. In C. J. Kibert (Ed.), *Reshaping the built environment: Ecology, ethics, and economics*. Washington, DC: Island Press.

Klem, L. (2000). Structural equation modeling. In L. G. Grimm & P. R. Yarnold. (Eds.), *Reading and understanding more multivariate statistics*. Washington, DC: American Psychological Association.

Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York: Guilford Press.

Kuo, F. E., Bacaicoa, M., & Sullivan, W. C. (1998). Transforming inner-city landscapes: Trees, sense of safety, and preference. *Environment and Behavior, 30*(1), 28-59.

Lawson, B. (1996). *Building materials, energy and the environment: Towards ecologically sustainable development*. Red Hill, ACT, Australia: Royal Australian Institute of Architects.

Lazarus, R. S. (1984). On the primacy of cognition. *American Psychologist, 39*(2), 124-129.

Leopold, A. (1981). *A sand county almanac and sketches here and there*. New York: Oxford University Press.

Lewin, K. (1967). *Field theory in social science: Selected theoretical papers.* London : Social Science Paperbacks.

Lubchenco, J. (1998). Entering the century of the environment: A new social contract for science. *Science, 279*, 491-497.

Lyle, J. T. (1994). *Regenerative design for sustainable development.* New York: John Wiley.

Lynch, K. (1960). *The image of the city.* Cambridge, MA: MIT Press.

Lynch, K. (1971). *Site planning* (2nd ed.). Cambridge, MA: MIT Press.

Lyons, E. (1983). Demographic correlates of landscape preference. *Environment and Behavior, 15*(4), 487-511.

MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. *Annual Review of Psychology, 51*, 201-226.

MacCallum, R. C., Roznowski, M., & Necowitz, L. B. (1992). Model modifications in covariance structure analysis: The problem of capitalization of chance. *Psychological Bulletin, 111*, 490-504.

Mackenzie, F. T. (1998). *Our changing planet: An introduction to earth system science and global environmental change.* Upper Saddle River, NJ: Prentice Hall.

Magnusson, D. (1981). Problems in environmental analyses–An introduction. In D. Magnusson (Ed.), *Toward a psychology of situations: An interactional perspective.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Maguire, M., Foote, R., & Vespe, F. (1997). Beauty as well as bread. *Journal of the American Planning Association, 63*(3), 317-328.

Maki, K., Inui, M., & Nakamura, Y. (1994). The consistency of streetscape evaluation structure. *Journal of Architecture, Planning and Environmental Engineering*, No. 458, 27-33.

Malin, N. (1999). Environmentally responsible building materials selection. In C. J. Kibert (Ed.), *Reshaping the built environment: Ecology, ethics, and economics.* Washington, DC: Island Press.

Maloney, M. P., & Ward, M. P. (1973). Ecology: Let's hear from the people: An objective scale for the measurement of ecological attitudes and knowledge. *American Psychologist, 28*, 583-586.

Maloney, M. P., Ward, M. P., & Braucht, G. N. (1975). Psychology in action: A revised scale for the measurement of ecological attitudes and knowledge. *American Psychologist, 30*, 787-790.

Mather, A. S., & Chapman, K. (1995). *Environmental resources*. Essex, England: Longman Scientific & Technical.

Mazmanian, D. A., & Kraft, E. M. (Eds.). (1999). *Toward sustainable communities: Transition and transformations in environmental policy*. Cambridge, MA: MIT Press.

McDonough, W. (1992). *The Hannover principles: Design for sustainability*. Retrieved June 2001, from http://www.virginia.edu/~sustain/HannoverPrinciples.html.

McGlen, N. E., Milbrath, L. W., & Yoshii, H. (1979). Cultural differences in perceptions of environmental problems. *Technological Forecasting and Social Change, 14*, 97-114.

McHarg, I. L. (1969). *Design with nature*. Garden City, NY: Doubleday/Natural History Press.

McIsaac, G. F., & Brün, M. (1999). Natural environment and human culture: Defining terms and understanding worldviews. *Journal of Environmental Quality, 28*(1), 1-10.

McKenzie-Mohr, D. (2000). Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of Social Issues, 56*(3), 543-554.

McKibben, B. (1989). *The end of nature*. New York: Random House.

McPherson, E. G., & Haip, R. A. (1989). Emerging desert landscape in Tucson. *Geographical Review*, 79(4), 435-449.

Meadows, D. H., & Club of Rome. (1972). *The limits to growth: A report for the Club of Rome's project on the predicament of mankind*. New York: Universe Books.

Meadows, D. H., Meadows, D. L., & Randers, J. (1992). *Beyond the limits: Global collapse or a sustainable future*. London: Earthscan.

Meyer, W. B. (1996). *Human impact on the earth*. New York: Cambridge University Press.

Middleton, N. (1999). *The global casino: An introduction to environmental issues* (2nd ed.). London; New York: Arnold.

Milbrath, L. W. (1989). *Envisioning a sustainable society: Learning our way out.* Albany, NY: State University of New York Press.

Milbrath, L. W. (1994). Stumbling blocks to a sustainable society. *Futures, 26*(2), 117-124.

Milbrath, L. W. (1995). Psychological, cultural, and informational barriers to sustainability. *Journal of Social Issues, 51*(4), 101-120.

Mobbs, M. (1998). *Sustainable house: Living for our future.* Marrickville, NSW, Australia: Choice Books.

Moore, G. T. (1979). Knowing about environmental knowing: The current state of theory and research on environmental cognition. *Environment and Behavior, 11*(1), 33-70.

Moore, G. T. (1987). Environment and behavior research in North America: History, developments, and unresolved issues. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology: Vol. 2.* New York: Wiley.

Moore, G. T., & Golledge, R. G. (1976). Environmental knowing: Concepts and theories. In G. T. Moore & R. G. Golledge (Eds.), *Environmental knowing: Theories, research, and methods.* New York: Van Nostrand Reinhold.

Moughtin, C. (1996). *Urban design: Green dimensions.* Oxford, England: Butterworth Architecture.

Mozingo, L. A. (1997). The aesthetics of ecological design: Seeing science as culture. *Landscape Journal, 16*(1), 46-59.

Nabhan, P. G. (1997). *Cultures of habitat: On nature, culture, and story.* Washington, DC: Counterpoint Press.

Nasar, J. L. (1984). Visual preferences in urban street scenes: A cross-cultural comparison between Japan and the United States. *Journal of Cross-Cultural Psychology, 15*, 79-93.

Nasar, J. L. (Ed.). (1988). *Environmental aesthetics: Theory, research, and applications.* New York: Cambridge University Press.

Nasar, J. L. (1989). Symbolic meanings of house styles. *Environment and Behavior, 21*, 235-257.

Nasar, J. L. (1994). Urban design aesthetics: The evaluative qualities of building exteriors.

Environment and Behavior, 26(3), 377-401.

Nasar, J. L. (1998). *The evaluative image of the city.* Thousand Oaks, CA: Sage.

Nasar, J. L., Julian, D., Buchman, S., Humphreys, D., & Mrohaly, M. (1983). The emotional quality of scenes and observation points: A look at prospect and refuge. *Landscape Planning, 10*, 355-361.

Nassauer, J. I. (1983). Framing the landscape in photographic simulation. *Journal of Environmental Management, 17*(1), 1-16.

Nassauer, J. I. (1989). The aesthetic benefits of agricultural land. *Renewable Resources Journal, 7*(4), 17-18.

Nassauer, J. I. (1992). The appearance of ecological systems as a matter of policy. *Landscape Ecology, 6*(4), 239-250.

Nassauer, J. I (1993). Ecological function and the perception of suburban residential landscapes. In P. H. Gobster (Ed.), *Managing urban and high-use recreation settings* (General Technical Report). St. Paul, MN: USDA Forest Service North Central Forest Experiment Station.

Nassauer, J. I. (1995a). Culture and changing landscape structure. *Landscape Ecology, 10*(4), 229-237.

Nassauer, J. I. (1995b). Messy ecosystems, orderly frames. *Landscape Journal, 14*(2), 161-170.

Nassauer, J. I. (1997a). Cultural sustainability: Aligning aesthetics and ecology. In J. I. Nassauer (Ed.), *Placing nature: Culture and landscape ecology*. Washington, DC: Island Press.

Nassauer, J. I. (1997b). Culture and landscape ecology: Insights for action. In J. I. Nassauer (Ed.), *Placing nature: Culture and landscape ecology*. Washington, DC: Island Press.

Newell, P. B. (1997). A cross-cultural examination of favorite places. *Environment and Behavior, 29*(4), 495-514.

Newman, O. (1972). *Defensible space: Crime prevention through urban design.* New York: Macmillan.

Noe, F. P., & Snow, R. (1990). The New Environmental Paradigm and future scale analysis. *Journal of Environmental Education, 21*(4), 20-26.

NSW Environment Protection Authority. (1997). *Who cares about the environment in 1997? Environmental knowledge, attitudes, skills and behaviours in NSW.* Chatswood, NSW, Australia: Environment Protection Authority.

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Olson, R. L. (1995). Sustainability as a social vision. *Journal of Social Issues, 51*(4), 15-35.

Orr, D. W. (1992). *Ecological literacy: Education and the transition to a postmodern world.* Albany, NY: State University of New York Press.

Oskamp, S. (1995). Applying social psychology to avoid ecological disaster. *Journal of Social Issues, 51*(4), 217-238.

Oskamp, S. (2000). Psychological contributions to achieving an ecologically sustainable future for humanity. *Journal of Social Issues, 56*(3), 373-390.

Oskamp, S., Harrington, M. J., Edwards, T. C., Sherwood, D. L., Okuda, S. M., & Swanson, D. C. (1991). Factors influencing household recycling behavior. *Environment and Behavior, 23*(4), 494-519.

Ostrom, E., Burger, J., Field, C. B., Norgaard, R. B., & Policansky, D. (1999). Revisiting the commons: Local lessons, global challenges. *Science, 284*, 278-282.

Palmer, J. F., & Hoffman, R. E. (2001). Rating reliability and representation validity in scenic landscape assessments. *Landscape and Urban Planning, 54*, 149-161.

Parsons, R. (1995). Conflict between ecological sustainability and environmental aesthetics: Conundrum, canärd or curiosity. *Landscape and Urban Planning, 32*(3), 227-244.

Parsons, R., & Daniel, T. C. (2002). Good looking: In defense of scenic landscape aesthetics. *Landscape and Urban Planning, 60*, 43-56.

Perkins, D. D., Brown, B. B., & Taylor, R. B. (1996). The ecology of empowerment: Predicting participation in community organizations. *Journal of Social Issues, 52*(1), 85-110.

Peron, E., Purcell, A. T., Staats, H., Falchero, S., & Lamb, R. J. (1998). Models of preference for outdoor scenes: Some experimental evidence. *Environment and Behavior, 30*(3), 282-305.

Peters, E., & Slovic, P. (1996). The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. *Journal of Applied Social Psychology, 26*(16), 1427-1453.

Peters, R. L., & Lovejoy, T. E. (1990). Terrestrial fauna. In B. L. Turner (Ed.), *The earth as transformed by human action: Global and regional changes in the biosphere over the past 300 Years*. New York: Cambridge University Press with Clark University.

Pezzoli, K. (1998). *Human settlements and planning for ecological sustainability: The case of Mexico City*. Cambridge, MA: MIT Press.

Pooley, J. A., & O'Connor, M. (2000). Environmental education and attitudes: Emotions and beliefs are what is needed. *Environment and Behavior, 32*(5), 711-723.

Princen, T. (1999). Consumption and environment: Some conceptual issues. *Ecological Economics, 31*(3), 347-363.

Punter, J. V. (1982). Landscape aesthetics: A synthesis and critique. In J. R. Gold & J. Burgess (Eds.), *Valued environments*. London: G. Allen & Unwin.

Purcell, A. T. (1986). Environmental perception and affect: A schema discrepancy model. *Environment and Behavior, 18*(1), 3-30.

Purcell, A. T., & Lamb, R. J. (1984). Landscape perception: An examination and empirical investigation of two central issues in the area. *Journal of Environmental Management, 19*(1), 31-63.

Purcell, A. T., Lamb, R. J., Peron, E. M., & Falchero, S. (1994). Preference or preferences for landscape? *Journal of Environmental Psychology, 14*, 195-209.

Purcell, A. T., Peron, E., & Berto, R. (2001). Why do preferences differ between scene types? *Environment and Behavior, 33*(1), 93-106.

Rapoport, A. (1977). *Human aspects of urban form: Towards a man-environment approach to urban form and design*. Oxford, England: Pergamon Press.

Rapoport, A. (1980). Cross-cultural aspects of environmental design. In I. Altman, A. Rapoport, & J. F. Wohlwill (Eds.), *Human behavior and environment: Advances in theory* *and research: Vol. 4. Environment and culture*. New York: Plenum Press.

Rapoport, A. (1990). *The meaning of the built environment: A nonverbal communication approach*. Tucson, AZ: University of Arizona Press.

Rapoport, A. (1994). *Sustainability, meaning, and traditional environments* (Traditional Dwellings and Settlements Working Paper Series, Vol. 75). University of California, Berkeley, Center for Environmental Design Research.

Rapport, D. J., Gaudet, C., Karr, J. R., Baron, J. S., Bohlen, C., Jackson, W., Jones, B., Naiman, R. J., Norton, B., & Pollock, M. M. (1998). Evaluating landscape health: Integrating societal goals and biophysical process. *Journal of Environmental Management, 53*(1), 1-15.

Ribe, R. G. (1989). The aesthetics of forestry: What has empirical preference research taught us? *Environmental Management, 13*(1), 55-74.

Rich, J. M. (1993). Assessment and control of school vandalism. *Education and Society, 11*(1), 65-70.

Richards, G. R. (1993). Change in global temperature: A statistical analysis. *Journal of Climate, 6*(3), 546-559.

Ridley, M., & Low, B. S. (1994). Can selfishness save the environment? *Human Ecology Review, 1*, 1-13.

Rochford, E. B., Jr., & Blocker, T. J. (1991). Coping with "natural" hazards as stressors: The predictors of activism in a flood disaster. *Environment and Behavior, 23*(2), 171-194.

Rokeach, M. (1968). *Beliefs, attitudes, and values: A theory of organization and change*. San Francisco: Jossey-Bass.

Ross, H., Dovers, S., Sexton, M., & Rodger, A. (Eds.). (1994). *Sustainability and the built environment: Interpretation and strategies* (Fundamental Questions Paper 12). Canberra: The Australian National University, Centre for Resource and Environmental Studies.

Russell, J. A. (1988). Affective appraisals of environments. In J. L. Nasar (Ed.), *Environmental aesthetics: Theory, research, and applications*. New York: Cambridge University Press.

Russell, J. A., Ward, L. M., & Pratt, G. (1981). Affective quality attributed to environments: A factor analytic study. *Environment and Behavior, 13*(3), 259-288.

Rustemli, A., & Karanci, A. N. (1999). Correlates of earthquake cognitions and preparedness behavior in a victimized population. *Journal of Social Psychology, 139*(1), 91-97.

Saito, Y. (1998). The aesthetics of unscenic nature. *Journal of Aesthetics and Art Criticism, 56*(2), 101-111.

Sancar, F. H. (1985). Toward theory generation in landscape aesthetics. *Landscape Journal. 4*(2), 116-124.

Schipper, L. (1996). Life-styles and the environment: The case of energy. *Daedalus, 125*(3), 113-138.

Schulhof, R. (1989). Public perceptions of native vegetation. *Restoration and Management Notes, 7*, 69-72.

Scott, A. (1998). Introduction: A time for change and innovation. In A. Scott (Ed.), *Dimensions of sustainability*. London: E & Fn Spon.

Scott, D., & Willits, F. K. (1994). Environmental attitude and behavior: A Pennsylvania survey. *Environment and Behavior, 26*(2), 239-260.

Seamon, D. (1987). Phenomenology and environment–behavior research. In E. H. Zube & G. T. Moore (Eds.), *Advances in environment, behavior, and design: Vol. 1*. New York: Plenum Press.

Selman, P. (1995). Local sustainability: Can the planning system help get us from here to there? *Town Planning Review, 66*(3), 287-301.

Sheets, V. L., & Manzer, C. D. (1991). Affect, cognition, and urban vegetation: Some effects of adding trees along city streets. *Environment and Behavior, 23*(3), 285-304.

Simmons, I. G. (1997). *Humanity and environment: A cultural ecology*. Harlow, England: Longman.

Smith, M., Whitelegg, J., & Williams, N. (1998). *Greening the built environment*. London: Earthscan.

Southwick, C. H. (1996). *Global ecology in human perspective*. New York: Oxford University Press.

Stamps, A. E., III (1990). Use of photographs to simulate environments: A meta-analysis. *Perceptual and Motor Skills, 71*, 907-913.

Stamps, A. E., III (1994). Formal and nonformal stimulus factors in environmental preference. *Perceptual and Motor Skills, 79*(1), 3-9.

Stamps, A. E., III, & Nasar, J. L. (1997). Design review and public preferences: Effects of geographical location, public consensus, sensation seeking, and architectural styles. *Journal of Environmental Psychology, 17*(1), 11-32.

Steiner, F., Young, G., & Zube, E. (1988). Ecological planning: Retrospect and prospect. *Landscape Journal, 7*(1), 31-39.

Stern, P. C. (2000). Psychology and the science of human-environment interactions. *American Psychologist, 55*(5), 523-530.

Stern, P. C., Dietz, T., & Guagnano, G. A. (1995). The new ecological paradigm in social-psychological context. *Environment and Behavior, 27*(6), 723-743.

Stern, P. C., & Gardener, G. T. (1981). Psychological research and energy policy. *American Psychologist, 36*, 329-342.

Strong, S. J. (1999). Introduction to renewable energy technologies. In C. J. Kibert (Ed.), *Reshaping the built environment: Ecology, ethics, and economics*. Washington, DC: Island Press.

Syme, G. J., Beven, C. E., & Sumner, N. R. (1993). Motivation for reported involvement in local wetland preservation: The roles of knowledge, disposition, problem assessment, and arousal. *Environment and Behavior, 25*(5), 586-606.

Taylor, D., & Rand, M. (1991). How to plan the nuisance out of wind energy. *Town & Country Planning, 60*(5), 152-155.

Tellegen, E., & Wolsink, M. (1998). *Society and its environment: An introduction.* Amsterdam: Gordon and Breach.

Thayer, R. L., Jr. (1989). The experience of sustainable landscapes. *Landscape Journal, 8*(2), 101-110.

Thayer, R. L., Jr. (1994). *Gray world, green heart: Technology, nature, and sustainable landscape.* New York: Wiley.

Thayer, R. L., Jr., & Freeman, C. M. (1987). Altamont: Public perceptions of a wind energy landscape. *Landscape and Urban Planning, 14*(5), 379-398.

Thering, S., & Doble, C. (2000). Theory and practice in sustainability: Building a ladder of community focused education and outreach. *Landscape Journal, 19*, 191-200.

Thompson, B. (2000). Ten commandments of structural equation modeling. In L. G. Grimm & P. R. Yarnold. (Eds.), *Reading and understanding more multivariate statistics*. Washington, DC: American Psychological Association.

Thorne, J. F., & Huang, C.-S. (1991). Toward a landscape ecological aesthetic: Methodologies for designers and planners. *Landscape and Urban Planning, 21*(1), 61-79.

Tips, W. E. J., & Savasdisara, T. (1986). Landscape preference evaluation and sociocultural background: A comparison among Asian countries. *Journal of Environmental Management, 22*(2), 113-124.

Todd, N. J., & Todd, J. (1994). *From eco-cities to living machines: Principles of ecological design*. Berkeley, CA: North Atlantic Books.

Tolba, M. K., & El-Kholy, O. A. (Eds.). (1992). *The world environment 1972-1992: Two decades of challenge*. London: Chapman and Hall.

Tuan, Y.-F. (1974). *Topophilia: A study of environmental perception, attitudes, and values.* Englewood Cliffs, NJ: Prentice-Hall.

Tuan, Y.-F. (1989). Surface phenomena and aesthetic experience. *Annals of the Association of American Geographers, 79*(2), 233-241.

Turner, F. (1994). The invented landscape. In A. D. Baldwin, J. De Luce, & C. Pletsch (Eds.), *Beyond preservation: Restoring and inventing landscapes*. Minneapolis, MN: University of Minnesota Press.

Ulrich, R. S. (1981). Natural versus urban scene: Some psychophysiological effects. *Environment and Behavior, 13*(5), 523-556.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman &

J. F. Wohlwill (Eds.), *Human behavior and environment: Vol. 6. Behavior and the natural environment*. New York: Plenum Press.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201-230.

United Nations, Population Division. (1999). *World population prospects: The 1998 revision*. New York: United Nations.

Vale, B., & Vale, R. (1991). *Green architecture: Design for a sustainable future*. London: Thames and Hudson.

Van der Ryn, S. (2000). Building ecology: Place, people, and pulse. In P. Knox & P. Ozolins (Eds.), *Design professionals and the built environment: An introduction*. New York: Wiley.

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

Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science, 277*, 494-499.

Ward, L. M., Snodgrass, J., Chew, B., & Russell, J. A. (1988). The role of plans in cognitive and affective responses to places. *Journal of Environmental Psychology, 8*(1), 1-8.

Weigel, R., & Weigel, J. (1978). Environmental concern: The development of a measure. *Environment and Behavior, 10*(1), 3-15.

Weinfurt, K. P. (1995). Multivariate analysis of variance. In L. G. Grimm & P. R. Yarnold (Eds.), *Reading and understanding multivariate statistics*. Washington, DC: American Psychological Association.

Wernick, I. K. (1996). Consuming materials: The American way. *Technological Forecasting and Social Change, 53*(1), 111-122.

West, S. G., Finch, J. F., & Curran, P. J. (1995). Structural equation models with nonnormal variables. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications: Problems and remedies*. Thousand Oaks, CA: Sage.

Westing, A. H. (1990). Our place in nature: Reflections on the global carrying-capacity for humans. In N. Polunin, & J. H. Burnett (Eds.), *Maintenance of the biosphere*. New York: St. Martin's Press.

Wines, J. (2000). *Green architecture*. Köln, Germany: Taschen.

Wohlwill, J. F. (1976). Environmental aesthetics: The environment as a source of affect. In I. Altman & J. F. Wohlwill (Eds.), *Human behavior and environment: Advances in theory and research: Vol. 1*. New York: Plenum Press.

Wood, D. (1988). Unnatural illusions: Some words about visual resource management. *Landscape Journal, 7*(2), 192-205.

World Commission on Environment and Development. (1987). *Our common future*. Oxford, England: Oxford University Press.

World Wildlife Fund for Nature. (1993). *Sustainable use of nature resources: Concepts, issues, and criteria*. Gland, Switzerland: WWF.

Yeang, K. (1995). *Designing with nature: The ecological basis for architectural design*. New York: McGraw-Hill.

Yeang, K. (1999). *The green skyscraper: The basis for designing sustainable intensive buildings*. Munich, Germany: Prestel.

Young, O. R., Stern, P. C., & Druckman, D. (Eds.). (1992). *Global environmental change: Understanding the human dimensions*. Washington, DC: National Academy Press.

Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist, 35*(2), 151-175.

Zajonc, R. B., & Markus, H. (1982). Affective and cognitive factors in preferences. *Journal of Consumer Research, 9*, 123-131.

Zube, E. H., & Pitt, D. G. (1981). Cross-cultural perceptions of scenic and heritage landscapes. *Landscape Planning, 8*(1), 69-87.

Zube, E. H., Sell, J. L., & Taylor, J. G. (1982). Landscape perception: Research, application and theory. *Landscape Planning, 9*(1), 1-33.

===== PART 1 =====

In the album handed to you, there are eleven photographs of outdoor scenes. I would like to know your impression of these scenes. Please look at the photographs and rate each one of them on the scales shown below. The scales have seven points ranging from one adjective (e.g., very interesting) at score 1 to its antonym (e.g., very boring) at score 7. On each scale, please circle the number that best describes your impression.

photograph 1 (house)

	very	fairly	somewhat	neither	somewhat	fairly	very	
interesting	1	2	3	4	5	6	7	boring
unattractive	1	2	3	4	5	6	7	attractive
natural	1	2	3	4	5	6	7	human made
cluttered	1	2	3	4	5	6	7	uncluttered
like	1	2	3	4	5	6	7	dislike
well maintained	1	2	3	4	5	6	7	not well maintained
inefficient	1	2	3	4	5	6	7	efficient
complex	1	2	3	4	5	6	7	simple
conspicuous	1	2	3	4	5	6	7	inconspicuous
beautiful	1	2	3	4	5	6	7	ugly

photograph 2 (drainage)

	very	fairly	somewhat	neither	somewhat	fairly	very	
interesting	1	2	3	4	5	6	7	boring
unattractive	1	2	3	4	5	6	7	attractive
natural	1	2	3	4	5	6	7	human made
cluttered	1	2	3	4	5	6	7	uncluttered
like	1	2	3	4	5	6	7	dislike
well maintained	1	2	3	4	5	6	7	not well maintained
inefficient	1	2	3	4	5	6	7	efficient
complex	1	2	3	4	5	6	7	simple
conspicuous	1	2	3	4	5	6	7	inconspicuous
beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
photograph 3	like	1	2	3	4	5	6	7	dislike
(research centre)	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
photograph 4	like	1	2	3	4	5	6	7	dislike
(windmill)	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
photograph 5	like	1	2	3	4	5	6	7	dislike
(wetland)	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
photograph 6 (house)	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
	like	1	2	3	4	5	6	7	dislike
	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
photograph 7 (park)	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
	like	1	2	3	4	5	6	7	dislike
	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
photograph 8 (apartment)	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
	like	1	2	3	4	5	6	7	dislike
	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
photograph 9 (house)	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
	like	1	2	3	4	5	6	7	dislike
	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
photograph 10 (pond)	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
	like	1	2	3	4	5	6	7	dislike
	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

		very	fairly	somewhat	neither	somewhat	fairly	very	
photograph 11 (commercial complex)	interesting	1	2	3	4	5	6	7	boring
	unattractive	1	2	3	4	5	6	7	attractive
	natural	1	2	3	4	5	6	7	human made
	cluttered	1	2	3	4	5	6	7	uncluttered
	like	1	2	3	4	5	6	7	dislike
	well maintained	1	2	3	4	5	6	7	not well maintained
	inefficient	1	2	3	4	5	6	7	efficient
	complex	1	2	3	4	5	6	7	simple
	conspicuous	1	2	3	4	5	6	7	inconspicuous
	beautiful	1	2	3	4	5	6	7	ugly

===== PART 2 =====

This time, I would like you to evaluate the outdoor scenes from an environmental point of view. Please look at the photographs again and evaluate each one of them by the criteria described below. The rating scale ranges from 'strongly disagree' at score 1 to 'strongly agree' at score 7. On each scale, please circle the number that best describes your evaluation. If you consider that the photographs do not contain sufficient information for you to make an evaluation, please simply assess the surrounding conditions based on your knowledge and experience. If you still find it difficult to make an evaluation, please circle 'U'.

	The house in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 1 (house)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The drainage in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 2 (drainage)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The research centre in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 3 (research centre)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The windmill in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 4 (windmill)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has <u>negative</u> environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The wetland in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 5 (wetland)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has <u>negative</u> environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The house in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 6 (house)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has <u>negative</u> environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The park in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 7 (park)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has <u>negative</u> environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The apartment in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 8 (apartment)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The house in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 9 (house)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The pond in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 10 (pond)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

	The commercial complex in this photograph	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree	
photograph 11 (commercial complex)	1. makes use of natural energy.	1	2	3	4	5	6	7	U
	2. is constructed with low impact on the environment.	1	2	3	4	5	6	7	U
	3. has negative environmental effects on surroundings.	1	2	3	4	5	6	7	U
	4. accompanies human activities caring for the environment.	1	2	3	4	5	6	7	U
	5. requires little energy to maintain.	1	2	3	4	5	6	7	U
	6. raises people's awareness toward the environment.	1	2	3	4	5	6	7	U

===== PART 3 =====

In this part, I would like to know your views on various environmental issues. Please read the following statements about our environment and choose your response from the scale ranging from 'strongly disagree' at score 1 to 'strongly agree' at score 7. On each statement, please circle the number that best describes your response.

	strongly disagree	disagree	somewhat disagree	neither	somewhat agree	agree	strongly agree
1. When humans interfere with nature, it often produces disastrous consequences.	1	2	3	4	5	6	7
2. All living beings (micro-organisms, plants, animals, and humans) are interdependent with one another.	1	2	3	4	5	6	7
3. Poisonous metals are introduced into the food chain, for instance, via ground water.	1	2	3	4	5	6	7
4. Humans were created to rule over the rest of the nature.	1	2	3	4	5	6	7
5. There are limits to growth beyond which our industrialized society cannot expand.	1	2	3	4	5	6	7
6. Humans are severely abusing the environment.	1	2	3	4	5	6	7
7. A change in climate caused by increased levels of CO_2 in the atmosphere is called the greenhouse effect.	1	2	3	4	5	6	7
8. To maintain a healthy economy, we will have to develop a 'steady-state' economy where industrial growth is controlled.	1	2	3	4	5	6	7
9. Humans must live in harmony with nature in order to survive.	1	2	3	4	5	6	7
10. Poisonous metals remain in the human body.	1	2	3	4	5	6	7
11. The world climate will probably massively change if CO_2 continues to be emitted into the atmosphere in as huge amounts as it is now.	1	2	3	4	5	6	7
12. The earth is like a spaceship with only limited room and resources.	1	2	3	4	5	6	7
13. Melting of the polar ice caps may result in a flooding of shores and islands.	1	2	3	4	5	6	7
14. A reduced number of species may interrupt the food chain, affecting some subsequent species in the chain.	1	2	3	4	5	6	7
15. The balance of nature is very delicate and easily upset.	1	2	3	4	5	6	7
16. Humans have the right to modify the natural environment to suit their needs.	1	2	3	4	5	6	7
17. Plants and animals exists primarily to be used by humans.	1	2	3	4	5	6	7
18. Fossil fuels (e.g. gas, oil) produce CO_2 in the atmosphere when burned.	1	2	3	4	5	6	7
19. We are approaching the limit of the number of people the earth can support.	1	2	3	4	5	6	7
20. Ozone near the ground may cause respiration problems.	1	2	3	4	5	6	7
21. Humans need not adapt to the natural environment because they can remake it to suit their needs.	1	2	3	4	5	6	7

===== PART 4 =====

Now, I would like to know about you.

Age: ____________

Gender: ☐ Male ☐ Female

Program: ______________________________

Year:
- ☐ Undergraduate First Year
- ☐ Undergraduate Second Year
- ☐ Undergraduate Third Year
- ☐ Undergraduate Fourth or Fifth Year
- ☐ Postgraduate (Master's)
- ☐ Postgraduate (Doctorate)
- ☐ Other (Please specify: __________________)

Language you learned first: __________________

If you have opinions concerning this survey, please describe in the area below.

Thank you very much for your time and cooperation.

===== PART 1 =====

ここに11枚の屋外の写真があります。それぞれの写真を以下の10のスケールで評価して下さい。スケールは一つの形容詞（例：「興味深い」）とその反対語（例：「つまらない」）を評価軸とした7段階からなっています。それぞれのスケールにおいてあなたの印象に最も近い番号を選び、○で囲んでください。

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真1（住宅）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真2（排水溝）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真 3（研究所）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真 4（風車）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真 5（湿地）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真6（住宅）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真7（公園）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真8（集合住宅）	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真 9 (住宅)	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真 10 (沼)	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

		非常に	かなり	やや	どちらでもない	やや	かなり	非常に	
写真 11 (商業施設)	興味深い	1	2	3	4	5	6	7	つまらない
	魅力的な	1	2	3	4	5	6	7	魅力的でない
	自然な	1	2	3	4	5	6	7	構築された
	乱雑な	1	2	3	4	5	6	7	整然とした
	好き	1	2	3	4	5	6	7	嫌い
	見捨てられている	1	2	3	4	5	6	7	手入れされている
	効率の良い	1	2	3	4	5	6	7	効率の悪い
	複雑な	1	2	3	4	5	6	7	単純な
	目立つ	1	2	3	4	5	6	7	目立たない
	美しい	1	2	3	4	5	6	7	美しくない

===== PART 2 =====

今度は環境的な視点からみなさんがそれぞれの写真についてどう考えるかをお聞きします。以下の6つの判断基準にもとづいてそれぞれの写真を評価して下さい。回答の選択肢は「非常にそう思う」から「まったくそう思わない」までの7段階からなっています。それぞれの判断基準においてあなたの考えに最も近い番号を選び、○で囲んで下さい。もし、写真からだけで判断するのが難しいと考えられる場合にはあなたが知る範囲で周辺状況を想定してみてください。それでも判断できないと考えられる場合には右端の「U」に○をつけてください。

	この写真にある住宅...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真1(住宅)	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

	この写真にある排水溝...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真2(排水溝)	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

	この写真にある研究所...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真3(研究所)	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

	この写真にある風車...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真4（風車）	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

	この写真にある湿地...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真5（湿地）	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

	この写真にある住宅...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真6（住宅）	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

	この写真にある公園...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
写真7（公園）	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

写真8 (集合住宅)	この写真にある集合住宅...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

写真9 (住宅)	この写真にある住宅...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

写真10 (沼)	この写真にある沼...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

写真11 (商業施設)	この写真にある商業施設...	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない	
	1. は自然エネルギーを利用している。	1	2	3	4	5	6	7	U
	2. は環境に対する負荷の低い方法で作られている。	1	2	3	4	5	6	7	U
	3. は周辺の生態系に悪い影響を与えている。	1	2	3	4	5	6	7	U
	4. では環境に配慮した行動が見られる。	1	2	3	4	5	6	7	U
	5. は小さなエネルギーで維持できる。	1	2	3	4	5	6	7	U
	6. は人々の環境問題に対する意識を高める。	1	2	3	4	5	6	7	U

===== PART 3 =====

ここではみなさんの環境問題全般に関する考え方をお聞きします。以下の文章についてのみなさんの考えを右側の選択肢から選んで答えてください。回答の選択肢は「非常にそう思う」から「まったくそう思わない」までの７段階からなっています。それぞれの文章において、あなたの考えに最も近い番号を選び、○で囲んで下さい。

	非常にそう思う	そう思う	どちらかというとそう思う	どちらともいえない	どちらかというとそう思わない	そう思わない	まったくそう思わない
1. 人が自然に関与すると、しばしば悲惨な結果をもたらす。	1	2	3	4	5	6	7
2. すべての生物（微生物、植物、動物、人）はお互い依存しあっている。	1	2	3	4	5	6	7
3. 毒性のある物質が食物連鎖の中に入ってきている。	1	2	3	4	5	6	7
4. 人間は自然を支配するように作られている。	1	2	3	4	5	6	7
5. 私たちの社会の成長には限界がある。	1	2	3	4	5	6	7
6. 人間は環境を乱用している。	1	2	3	4	5	6	7
7. 大気中の二酸化炭素の増加によって起こる気象の変化を「温室効果」と呼ぶ。	1	2	3	4	5	6	7
8. 健全な経済活動を維持するためには産業の成長をコントロールできる安定した経済状況を作り出す必要がある。	1	2	3	4	5	6	7
9. 人々は自然と調和して暮らさなくてはならない。	1	2	3	4	5	6	7
10. 毒性のある物質は人間の体内に残る。	1	2	3	4	5	6	7
11. 二酸化炭素の大気への排出が現状のまま続けば、世界の天候は大きく変わることが予想される。	1	2	3	4	5	6	7
12. 地球は限られた空間と資源しか持たない宇宙船のようなものである。	1	2	3	4	5	6	7
13. 極地の氷がとけることにより、陸地の海岸部で洪水が起こる。	1	2	3	4	5	6	7
14. 生物種の数の減少が食物連鎖を乱し、他の種に影響を与えることが考えられる。	1	2	3	4	5	6	7
15. 自然のバランスは微妙なので、その均衡は簡単に崩れる。	1	2	3	4	5	6	7
16. 人間はその必要を満たすために環境を変える権利を持つ。	1	2	3	4	5	6	7
17. 石油、ガスなどの化石燃料が燃えると二酸化炭素が発生する。	1	2	3	4	5	6	7
18. 動植物は主に人々によって使われるために存在する。	1	2	3	4	5	6	7
19. 人類の人口は地球がサポートできる限界に近づいている。	1	2	3	4	5	6	7
20. 地表近くのオゾンは呼吸に問題をもたらす。	1	2	3	4	5	6	7
21. 人々はその必要に応じて自然環境を作りかえることができるので、環境に適応する必要はない。	1	2	3	4	5	6	7

===== PART 4 =====

最後にあなたご自身のことについてうかがいます。

年齢：＿＿＿＿＿＿

性別：☐ 男性　☐ 女性

専攻：＿＿＿＿＿＿＿＿＿＿＿＿

学年：☐ 学部１年生
☐ 学部２年生
☐ 学部３年生
☐ 学部４年生
☐ 大学院修士課程
☐ 大学院博士課程
☐ その他（＿＿＿＿＿＿＿＿）

この調査に関して不明な点、ご意見、ご質問等ありましたら以下にお書き下さい。

ご協力ありがとうございました。

Appendix B1

Specific Information for Treatment Group 1 (English)

Photograph 1

(House)

It is a recent trend in American society that the modern suburban house is becoming larger. Their size is often determined not by necessity but by social status. However, larger houses consume more energy and resources than smaller ones both in their initial construction and in cooling/heating of their interiors. In addition, in order to secure a large building lot, the larger houses tend to be built at a distance from city centres. Since public transportation is not feasible for low density suburbs, those who live in these suburbs have to rely on private cars for commuting and shopping. This results in three-car garages as can be seen in this photograph.

Photograph 2

(Drainage)

In this residential area, street drainage is channeled through notched curbs directly into this natural swale system, which is planted with a variety of vegetation. Drainage water then percolates into the soil. The system is designed to be capable of absorbing a ten-year storm event entirely on site. This system of returning water to the local soil has several advantages over a conventional system. First, the energy and resources necessary to install a conventional stormwater system can be saved. Secondly, it prevents lowering the local ground water table. Finally, it provides a natural environment for various plants and organisms.

Photograph 3

(Research centre)

The research centre shown in this photograph employs state-of-the-art technology to reduce energy consumption in the building. The building is enveloped by two layers of glass, one of which is equipped with adjustable louvres that control the amount of sunlight into the building. Air space between the two layers of glass is used to introduce fresh air from outside and to exhaust hot inside air. The combined use of these technologies with a climate monitoring system makes it possible to control the interior climate with a relatively low expenditure of energy.

Photograph 4

(Windmill)

Wind power generation is one of the most promising alternatives to conventional energy which relies on fossil fuels or nuclear power. In advanced countries such as Germany and Denmark, wind power generation is expected to bear 10% of the whole energy consumption of the country in the near future. In addition, wind power is not only clean energy but also enables multiple land use, such as grazing as can be seen in this photograph.

Photograph 5

(Wetland)

This wetland was constructed to treat stormwater collected from nearby neighbourhoods. In a conventional stormwater system, rain water is collected into underground water pipes, then discharged into the ocean. This means that the water has little chance of returning to the soil where it fell, thereby depriving local groundwater. It also means impoverished local ecosystems and more chance of flooding due to a higher speed of water accumulation. In addition, since the conventional system is completely hidden from our sight, it becomes something people do not care. By keeping the water and letting it seep into the soil, the wetland solves those problems inherent in the conventional stormwater system.

Photograph 6

(House)

The entire roof of this house is covered with solar panels that produce electricity. The panels are connected to a power grid so that electricity not used during the day can be sold to a utility company. The ratio between energy production and consumption depends on various factors such as climate, use of other energy sources, insulation, family organization and living patterns. However, simulations found that under typical conditions, the annual production of electricity by the panels can exceed annual consumption. Since the cost of a solar panel is expected to decrease due to increased demand, solar energy will become a favoured option not only environmentally but also economically.

Photograph 7

(Park)

Since lawn is 'green,' it is often not considered as potentially harmful to the environment. However, it sometimes has an adverse effect to the environment. In order to maintain its lushness, lawn requires a considerable amount of herbicides and pesticides, which degrade its surroundings as well as nearby rivers, lakes and the sea, thus posing health risks for people, animals and plants. Another problem is the failure of conventional lawn to provide for biodiversity: it is not suitable for habitat or movement of species. Furthermore, due to its low water retention, it accelerates surface water run-off rates, which acts to lower the groundwater table and contributes to downstream flooding.

Photograph 8

(Apartment)

The situation of an apartment where a large number of people live together can have the effect of reducing stress on the environment by concentrating the use of public facilities. This renovated apartment employs various techniques to further decrease energy consumption. The shape and location of the buildings were designed to optimize the benefit from the sun and wind. Roof and wall vegetation are incorporated to reduce the heat load during the summer. Another feature of this apartment is that residents, architects and local government worked together on the renovation plan, thus the apartment aims to achieve sustainability not just by physical measures but also by social cooperation within the community.

Photograph 9

(House)

The wall and roof of this house are covered with soil and various plants. Due to evaporation from the plants and the insulating effect of the soil, the interior temperature is kept low during the daytime in summer. During the night in summer and all day in winter, the insulation of the soil acts to prevent the interior heat from escaping. Thus the energy required to heat and cool this house is considerably lower in comparison to conventional houses in the same area.

Photograph 10

(Pond)

This pond was reconstructed from a concrete covered basin by dredging sludge, replacing the concrete surface with soil, and planting various water plants. After this renovation, the water quality of the pond improved considerably, and the pond now provides a habitat suitable for fish and insects to live and breed. The pond contributes to the environment by enhancing the biodiversity of this area. In addition, it offers the chance for people, especially children, to observe the natural cycle of numerous aquatic insects. Thus, the pond plays an important role not only in a local ecosystem but also in environmental education.

Photograph 11

(Commercial complex)

It is a common criticism that the waste from demolished buildings contribute a considerable volume to the total industrial wastes to be incinerated or used as landfill. Therefore, reusing and recycling used construction materials, and extending the life of buildings are effective means of reducing man's impact upon the environment. The commercial complex shown in this photograph utilizes many recycled and reused materials. Where new materials are necessary, the building uses biodegradable materials that will have less impact on the environment at the time of disposal. In order to achieve sustainability in architecture, the total amount of resources necessary to construct, maintain and demolish buildings needs to be considered.

Appendix B2

Specific Information for Treatment Group 1 (Japanese)

写真 1

(住宅)

アメリカ郊外に建つ住宅は床面積が大きいものが多い。大きな家ではゆとりのある生活が可能であるが、ステータスシンボルのため必要以上に大きな住宅が購入される場合も多い。その結果、住宅建設に大きな資源とエネルギーが必要となるだけでなく、冷暖房など日常の生活に必要なエネルギーも大きくなる。また大きな敷地面積を確保するため、このような住宅地は都市中心部から離れ、その人口密度も低くなるため、公共交通サービスが提供されない場合がほとんどである。したがって通勤や買い物には自家用車が必要不可欠となり、この写真にあるように3台分のガレージを持つ住宅も増えている。

写真 2

(排水溝)

この住宅地においては、街路にそって集められた雨水がこの植物におおわれた浅い溝に集められ、地中にしみこむようになっている。この自然を利用した排水システムは10年に一度の大雨の際にも雨水を完全に現地で吸収できるようにデザインされている。このような現地処理型の排水システムは排水管の設置等に必要な資源やエネルギーを節約できるだけでなく、地下水位低下の防止、多様な植物や生き物の生息地の確保といったメリットも持っている。

写真 3

(研究所)

この研究所は最新の省エネルギー技術を使って建てられたものである。建物は二層のガラスによって外部から仕切られており、一方のガラスに取り付けられたルーバーにより太陽光線の入射量を必要に応じて調整することができる。またガラス層の間の空気のスペースを使って、外気の導入や内部の空気の放出などが行われ、建物内部の温熱環境を比較的小さなエネルギーでコントロールすることが可能となっている。

写真 4

(風車)

風力発電は化石燃料または原子力に依存する現在の発電方法に代わる新しい電力としてもっとも期

待されているものである。ドイツやデンマークなどの先進国においては、国内エネルギー需要の10%程度を風力でまかなう時代が近い将来やってくると予想されている。また風力発電は環境への影響が非常に低いクリーンなエネルギーであることの他に、その土地を放牧などの発電以外の目的にも使うことができ、土地も有効に利用される。

写真5

(湿地)

この湿地は近隣の住宅地から集められた雨水を処理するために人工的に作られたものである。一般的に住宅地において屋根、道路から集められた雨水は、地下の雨水管を経て、最終的には海に戻される。しかしながら、このような人工的システムは雨が浸透しない舗装面積の増加も手伝って地下水位の低下や洪水の増加などの原因ともなっている。またシステム自体がほとんど見えないことから、雨水の循環が私たちに意識されないブラックボックスになっているという点も指摘できる。この湿地はこれらの問題を解決するばかりではなく、その土地の植物、鳥などの動物、昆虫、微生物の生息地としての役割も果たしている。

写真6

(住宅)

この住宅の屋根は全面、太陽電池パネルでおおわれている。太陽電池パネルにおいて発電された電力は住宅で使われる他、余剰分は電力会社に売電することが可能である。太陽電池パネルでの年間発電量と住宅での消費量の関係は気象条件やその他のエネルギー源（石油、ガスなど）の使用の有無、家族構成、生活パターン等によっても大きく異なるが、発電量が消費量を上まわることもある。今後、太陽電池パネルの生産量の増加に伴い、そのコストも減少することが予想されており、経済的に見ても太陽光利用のメリットが大きくなると考えられる。

写真7

(公園)

芝生は植物であることから、一般的には環境に悪い影響を与えているようには考えられていないが、実際には環境をそこなういくつかの問題を持っている。まず芝生を緑に保つためには多量の肥料や除草剤が必要であり、これは長期的には付近の動植物に悪い影響を与え、川・湖・海などの汚染の原因ともなっている。また芝生は保水能力が低いため地下水位の低下や下流部での洪水を招くことがある。さらに芝生はいろいろな動物や昆虫類の生息および移動に適していないことから、生物の多様性という点においても問題が指摘されている。

写真 8

(集合住宅)

集まって住むことは都市施設の有効利用などの面でそれ自体にも環境への負荷軽減の効果がある。この集合住宅ではさらに光や風の向きを考慮に入れた建物配置や、一部の壁面と屋根での緑化を組み合わせることにより、自然の力で暑さや寒さを緩和し、住宅におけるエネルギー消費を減らすよう工夫されている。この集合住宅は住民たちが建築家や行政と共同で計画を進めてきたものであり、コミュニティの形成を重視して作られてきたことも大きな特徴である。ここに住む人たちが協同して問題に対処できるような集住の形態が模索されている。

写真 9

(住宅)

この住宅の壁面と屋根は多くの植物や土におおわれている。植物の蒸散作用や土の断熱材としての機能により、夏の昼間は日射による室内の温度上昇がおさえられ、また夜間や冬季は室内の熱が外部へ拡散するのが抑制されている。したがって、このような住宅においては冷暖房に必要なエネルギーを一般的な住宅に較べて低く抑えることが可能となる。

写真 10

(沼)

これは以前にあったコンクリート護岸の池をヘドロの浚渫(しゅんせつ)、コンクリートに代わる土砂の使用、水草の植栽などにより、このような沼に作り直したものである。この改良工事により、水質が浄化され、多くの魚介類や水生昆虫類が住めるような環境が作り出された。この沼そのものが生物の多様性向上などの面で環境の向上に寄与しているが、他方でボランティア活動やそれを通じた環境教育の現場ともなっており、環境の重要性を伝える役割も果たしている。

写真 11

(商業施設)

産業廃棄物にしめる建築廃材の割合はかなり高く、建築材料を再利用すること、また建築物の長寿命化を達成することは環境に対する負荷を低減するという意味において非常に重要である。この商業施設の多くの部分においては一度使われた建築材料が再利用されている。また、新しい材料が使われた部分においても廃棄時に環境への負荷が小さい自然な材料が使われており、この建物は建築材料を通じて環境に配慮したものとなっている。

Appendix C1

General Information for Treatment Group 2 (English)

Following the Industrial Revolution, there has been a massive expansion in human activities in population, energy consumption and mobility. Development in the latter half of the 20th century, in particular, has been enormous in its scale and speed. The human population has more than doubled in this period, and the average energy consumption per person has nearly tripled. This means a sixfold increase in man's impact on the earth in just 50 years. Many researchers are warning that if this tendency continues, the earth will sooner or later face a critical situation in various facets of the environment such as resource depletion, severe weather change due to global warming, loss of biodiversity and food shortages.

The intensive level of human development can be seen to have a direct link with these environmental problems. A key factor is that our current development practices do not acknowledge a limited capacity of the environment and resources. It should be emphasized that there is a limit to the earth's resources and the regenerative capacity of the environment. Since no technology seems capable of making them infinite, we need to use natural resources and the environment in a sustainable manner. To this end, future development needs to address the following three imbalances caused by past development.

First, development by humans so far has neglected nonhuman species and associated ecological systems. However, all the species on the earth are interdependent on each other, and man is no exception. Since the existence of man is dependent on that of other species, any development should enable other species to live and ecological systems to maintain their functions.

Secondly, past development has expended resources and disturbed ecosystems at rates faster than that which can be compensated by the regeneration of those resources and ecosystems. In pursuit of a short-term profit, this type of development sacrifices long-term benefits from the resources and ecosystems that future generations are entitled to recieve.

Finally, wealthy industrial countries that have only 20% of the total population consume 80% of the total resources on the earth. This trend of extremely uneven distribution of resources is getting worse both at the national and international levels. If the tendency persists, most of the resources available will be consumed by a small percentage of economically powerful people.

Above imbalances between humans and the other species, between generations, and between the rich and the poor are unavoidable problems we need to resolve to achieve a sustainable society. A UN organization proposes the following measures to cope with these problems:

- to maintain various systems that support life on earth (atmosphere, ozone layer, water circulation system, soil, ecosystems);
- to use regenerative resources (forest, cultivated lands, fishery area) in a sustainable manner;
- to minimize the use of non-regenerative resources (fossil fuel);
- to acknowledge the limited capacity of the earth, and to realize a life pattern that is based on this recognition;
- to change individual life styles and customs;
- to organise local communities that can protect the local environment;
- to implement national policies that balance environmental protection and development;
- to establish international support systems for the environment.

What is necessary now is to propose action plans based on the above principles to promote the concept of sustainability, and realize them on an individual, regional, national and international level.

Appendix C2

General Information for Treatment Group 2 (Japanese)

人類の長い歴史を考えたとき、産業革命を境にして人類の活動は人口、エネルギー消費量、交通による移動能力（モビリティ）などの点において飛躍的な成長をとげてきた。なかでも20世紀後半の成長はめざましく、過去50年間で地球の全人口は2倍以上、一人あたりの平均エネルギー資源使用量は約3倍となっており、たった半世紀のうちに人類が地球に与える負荷は単純に計算してもおよそ6倍にもなってしまっている。このような傾向が今後も続けば、遠からぬ将来、資源の枯渇、さらなる気候変動、生物多様性の崩壊（種の絶滅）、耕地面積・漁場の減少による食糧問題など、環境の多くの側面において危機的な状況になることが研究者によって指摘されている。

これまでに地球上で行われてきた開発・発展のための人間の営みがこのような環境問題の原因であるということができるが、現在の開発の大きな問題の一つは環境・資源の有限性が認識されてこなかったことである。地球の持つ資源や環境の再生能力には限界があり、どんな技術を持ってしてもそれを無限にすることはできない。今後の開発はまずこの有限性を前提とすることが必要であり、その上で環境・資源をいかに有効にまた公平に使っていくかが重要なポイントとなる。そのためには以下の三つの問題が検討されなくてはならない。

まずこれまでの人間による開発は他の生物種やそれらを含む生態系を無視し、その存続を危うくしてきたといえる。地球上のすべての生命は一つの大きな相互依存システムの一部であるが、人間の活動規模の急激な増大により、私たちによる生態系への影響も飛躍的に増加している。しかしながら、人間という種の存続が他の生物種の利用に依存していることは明らかであり、これからの開発はそれらを単に搾取の対象とするのではなく、他生物種との共生を可能にし、その生態系を維持するようなものであることが求められる。

またこれまでの開発は私たちの子孫の世代への配慮をすることなく、無計画に資源を搾取し、また許容量をこえて環境に過度な負荷をかけてきた。このような開発は次世代が環境から受けるであろう恩恵を犠牲にした上で成り立っているものであり、単なる資源・環境の搾取にとどまらず、子孫のニーズが満たされなくなる危険性を持つという意味においても深刻な問題である。

さらに、資源消費を地球規模で見ると世界人口の2割にすぎない先進工業国が全体の資源・エネルギーの8割を独占的に消費するという極度に偏ったパターンに陥っている。このような格差は国際

的にも国内的にもますます開く傾向にあり、このままでは経済力を持った一部の人々だけが、地球資源の大半を独占し、使いつくしていくことになってしまう。

このような人間と他の生き物たち（生態系）との間、世代間、富める地域と貧しい地域の間の不均衡（搾取する／される）は今後の環境を考える上で避けて通ることのできない問題であり、「持続可能」な社会を達成するためにはこれらの問題を解決してくことが必要である。ある国連の研究機関はこれらの問題に取り組むための次のような原則となる指針を提案している。

・地球上の生命を支える諸システム（大気、オゾン層、水循環システム、土壌、生態系等）の保全
・生物学的多様性の保護
・再生可能な資源（森林、耕作地、土壌、漁場等）の持続可能な利用
・再生不可能な資源（化石燃料等）の消費の最小限化
・地球の収容能力の限界の認識とそれに基づいた生活様式の実現
・個人の生活態度と習慣の変更
・地域社会で環境を守っていけるような仕組みづくり
・開発と環境保全を統合する国家的枠組みの策定
・地球規模の協力体制の確立

今後必要なことは、これらの原則に従って持続可能な社会のための実際的戦略を立てることであり、それらを個人、地域、国内、国際的なレベルで実践に移していくことである。

The University of Sydney

Faculty of Architecture

NSW 2006 AUSTRALIA

College of Sciences and Technology

Takemi Sugiyama
PhD Candidate

Wilkinson Building G04
Telephone +61 2 9351 5914
Facsimile +61 2 9351 3855
email sugiy_t@arch.usyd.edu.au

Participant Information Statement

Title of the study
Preferences for sustainable design: The roles of cognitive evaluation, knowledge, attitudes and culture

Purpose of the study
You may be aware of some of the environmental problems our societies are facing at this time. In order to alleviate the problems, environmental designers such as architects, landscape architects and urban planners have been constructing environmentally conscious buildings and facilities. What matters here is not only the buildings and facilities but also the way we use them. Previous studies have found that people's feelings and thoughts about a certain environment affect the way they treat the environment and behave in it. Thus in this survey, we would like to know your feelings and thoughts concerning various environmentally friendly (and unfriendly) facilities.

The findings of this study will provide important insights into our perception of environmentally conscious facilities. It is expected that the survey will identify various factors that influence our perceptions. This information will assist environmental designers to construct facilities that are more acceptable, and thus can be sustained by the appropriate care of users.

Method
In this survey, we use a questionnaire and a set of photographs of outdoor scenes. The questionnaire consists of four parts. Parts 1 and 2 identify your responses to the pictures. Parts 3 and 4 collect background information. It should take about 40 minutes to complete the whole questionnaire.

Personal information and confidentiality
Personal information such as your name and address is not required. However, we ask you to write your age, gender and the language you first learned. Your first language is necessary for cultural comparison. (The same survey has been done in Japan.) The above information as well as your answers will be kept confidential and used only for the purpose of this survey. The raw data obtained in this survey is accessible only to the researchers shown below.

Important notice
It is very important that you give us your honest opinions. Unlike examinations, there are no right or wrong answers. So please answer the questions as truthfully as possible.
Please also note that your participation in the survey is voluntary and you are free to withdraw at any time without penalty or prejudice.
If you have any concerns or complaints about the conduct of a research study, please contact the Manager of Ethics and Biosafety Administration, University of Sydney (Phone 02 9351 4811)

Researchers
Student: Takemi Sugiyama (Phone 02 9351 5914)
Supervisor: Professor Gary T Moore

Many thanks,
Professor Gary T Moore, Takemi Sugiyama

(page 1 of 1)

The University of Sydney

Faculty of Architecture

NSW 2006 AUSTRALIA

College of Sciences and Technology

Takemi Sugiyama
PhD Candidate

Wilkinson Building G04
Telephone +61 2 9351 5914
Facsimile +61 2 9351 3855
email sugiy_t@arch.usyd.edu.au

調査の概要

研究タイトル
持続可能性をめざしたデザインに対する環境選好に関する研究

調査の目的
私たちの社会が現在直面している「環境問題」についてはみなさんご存じだと思いますが、この問題を解決するために、建築や造園、都市計画などの分野にかかわる人たちが環境に配慮した建物、公園、都市を作ろうとしています。ここで重要となるのは建物や都市そのものだけではなく、それらが人々によってどう使われるかという点です。そこでこの調査ではそのような環境に配慮したさまざまなデザインについてみなさんがどう感じるか、またどう考えるかを調べることを目的としています。

調査の方法
この調査はいくつかの屋外の写真とそれに関する一連の質問からなっています。質問は四つの部分から構成されていて、Part 1とPart 2では写真に関するみなさんの印象や考えを聞きます。Part 3とPart 4ではみなさんが環境一般に関してどう考えるかなどの情報を集めます。すべての質問に答えるには30分程度かかります。

個人情報について
この調査は匿名で行われますが、年齢、性別、専攻、学年、母国語については記入が求められます（母国語は他文化との比較において必要となります）。上記の情報及び回答は調査以外の用途に利用されることはなく、回答された質問票は以下の研究者以外には開示されません。

その他
この調査には「正しい答え」や「間違った答え」はありませんので、思った通りを正直に回答してください。また、この調査はみなさんの大学のカリキュラムとはまったく別のものであり、回答はいかなる形においてもみなさんの成績や評価に影響を与えることはありません。
また調査への参加は強制的なものではありません。みなさんには調査に参加しない、あるいは質問に答えない権利があります。

研究者
杉山岳巳 (PhD candidate, University of Sydney)
Gary T Moore (Professor, University of Sydney)

調査へのご協力、感謝します。

(page 1 of 1)

The University of Sydney **Faculty of Architecture**

NSW 2006 AUSTRALIA

College of Sciences and Technology

Takemi Sugiyama
PhD Candidate

Wilkinson Building G04
Telephone +61 2 9351 5914
Facsimile +61 2 9351 3855
email sugiy_t@arch.usyd.edu.au

Consent Form

I have been asked to participate in the following survey:

Title:	Preferences for sustainable design: The roles of cognitive evaluation, knowledge, attitudes and culture
Student:	Takemi Sugiyama (Phone 02 9351 5914)
Supervisor:	Professor Gary T Moore

I give my consent by signing this form on understanding:

1. the general purposes and methods of the survey,
2. that I may withdraw at any time, and may refuse to answer questions put to me by the researchers,
3. that any information obtained in this survey, if published, will not contain the names and addresses of participants,
4. that this research project has been approved by the University of Sydney Human Ethics Committee,
5. that I understand that any person with concerns or complaints about the conducts of a research study can contact the Manager of Ethics and Biosafety Administration, University of Sydney (Phone 02 9351 4811),
6. that I confirm that I have read the Participant Information Statement and Consent Form.

Full name of participant: ....

Signature: .... Date: ....

Student's name: Takemi Sugiyama

Student's Signature: .... Date: ....

(page 1 of 1)

The University of Sydney
Faculty of Architecture

NSW 2006 AUSTRALIA
College of Sciences and Technology

Takemi Sugiyama
PhD Candidate

Wilkinson Building G04
Telephone +61 2 9351 5914
Facsimile +61 2 9351 3855
email sugiy_t @arch.usyd.edu.au

承諾書

私は以下の研究者による調査に参加するよう依頼されました。
研究者: 杉山岳巳
指導教官: Professor Gary T Moore
研究タイトル：「持続可能性をめざしたデザインに対する環境選好に関する研究」

私は「調査の概要」とこの「承諾書」を読み、以下の項目を理解したうえで、所定の欄に署名することによりこの調査に参加することを承諾します。

1. この調査の目的
2. 参加者が調査のどの段階においても参加をとりやめることができ、またどの質問にも答えることを拒否できること
3. この調査から得られた結果が公表される場合は参加者の名前や住所が含まれないこと
4. この調査がシドニー大学倫理委員会によって承認されていること
5. この調査に対する意見や不平がある場合は担当教員を通じてシドニー大学倫理委員会に申し立てすることができること

参加者署名：____________________ 日付：____________________

研究者署名：____________________ 日付：____________________

(page 1 of 1)

Appendix F

Publications and Presentations Arising from this Research

Publications

Sugiyama, T. (1999). Human perception of sustainable environments: Toward a new planning approach. *Retrospect and Prospect for Regional Development Towards 21st Century: Proceedings of International Symposium on City Planning 1999*, Tainan. Chinese Institute of Urban Planning, pp. A31-38.

Sugiyama, T. (2001). The perceptual aspect of sustainable design: Environmental preference and unresolved issues. *MERA Journal, 7*(1), 1-10.

Sugiyama, T. (2002). Perception of sustainable design: An empirical examination of environmental preference and evaluation of sustainability. *Journal of Architecture, Planning and Environmental Engineering*, No. 552, 93-99.

Presentations

Sugiyama, T. (2000). Environmental preference and environmental sustainability. [Abstract]. *Proceedings of 31st Annual Conference of the Environmental Design Research Association*, p. 107. (abstract refereed)

Sugiyama, T. (2001). Preference for sustainable design: Analysis of empirical data. [Abstract]. *Proceedings of 32nd Annual Conference of the Environmental Design Research Association*, p. 259. (abstract refereed)