

LIFE STYLE AND HOUSING CHOICE IN THE CITY OF BANDUNG, INDONESIA

by

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## ABSTRACT

The development of planning theory and housing approach in the past has been dominated by modernism. Recently, the modernist approach has been challenged for its "bounded rationality", resource limitation, and "value-free" pretence. The postmodernist approach is an "experiment" that emerges from a disappointment with the modernist's "value-free", rational, mechanistic and rigid approach. Without intending to be "postmodernist", this housing research utilises both modern rational scientific method and intuitive appreciation to get insight into housing choice and proposes a "culture-based" planning approach - an approach that appreciates diverse values, styles, or cultures of actors involved in planning activities and aims at a holistic material and spiritual development.

The description of urban housing issues in Southeast Asia, including Indonesia, has clarified the recent emphasis on solving physical problems and financial constraints. With the intention to promote a "culture-based" planning approach, this research searches for a housing approach that may be sensitive to value differences rather than simply physical standards. The examination of Indonesian urban housing issues reveals a lack of information on the association between "household type" and housing preferences which is required for this approach. Hence, it utilises a life style theoretical framework to identify differences in housing preferences among urban households in the City of Bandung and (intuitively) appreciate subtle value orientations behind the housing preferences.

To assess urban housing choices that derive from household life styles, households are clustered according to their life styles, and their housing choices are examined on the basis of this clustering. The central thesis is that differences in household life style may colour the differences in housing choice, thus developers, planners or policy

makers can improve the planning for, and provision of, urban housing by taking into account these associated differences.

For practical purposes, the research is designed to identify life style groups through a set of 16 socio-economic-cultural-demographic variables which are, hypothetically, believed to discriminate between different types of life styles. It uses Nonlinear Principal Component Analysis to reduce the 16 variables into 6 components or dimensions before doing cluster analysis. Assuming that the groupings through cluster analysis represent life-style groupings, it is found that life-style groupings and housing preferences are associated. While income segmentation better predicts some (cost-related) housing preferences, life style segmentation better predicts some other housing preferences. However, the predictive power of income segmentation on housing preference is much higher in the life style groups than in the aggregate sample. All of these findings show the potential of life-style identification for urban housing comprehension.

Due to the limitation of the sample, this study should be seen as a preliminary or exploratory study of life style grouping and housing choice within an Indonesian metropolitan area. However, the study has been able to identify and describe some characteristics of nine urban life styles and their housing implications. It improves the comprehension of urban housing preference through a life-style perspective. It also explores the possibility of applying this understanding to the process of planning urban housing. More generally, it provides another direction for urban housing study, particularly in the development of "culture-based" planning theory and housing policy.

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Scientific enquiry is the standard Western approach to almost any question. It seems to encapsulate the Western outlook on the world. Within this scientific paradigm, we need to understand, rationally, the process before we feel able to commit ourselves to it; we feel the need to explore intellectually before we feel able to experience personally; we need to prove to ourselves that something will be worth doing before we can act. Scientific results are interesting in their own right and research will add to the body of knowledge. However, even when we understand (rationally) the mechanics of the process we cannot claim to know any more than that. The mystery of life remains and cannot be explored by scientific method. It can only be personally experienced through the intuitive appreciation that "understands" the world by directly living in, by approaching the reality as a continuum between subject and object.

For my wife, Lena Magdalena,  
my mother, Elly,  
and my children, Dei and Deo,  
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## Chapter I

### INTRODUCTION

...our present age, [is] a time of the most profound disjunctions of intellectual and spiritual worldviews since the nova of scientific knowledge of about half millenium ago... Some postmodern scholars seem to conclude, as the Buddha did twenty-five hundred years ago, that in the stream that is Nature there exists no constant, no certainty, no Truth even, save flux itself... Change is Nature's preeminent observable hallmark: whirl is king, as Aristophanes said. To speak the truism that no one step into the same river twice, however, is not to suggest that there is no river. Like the waves, vortices and currents in any stream, the unrelenting fluxes which we witness and experience are evanescent concentrations, assemblages and configurations of an irreducible river of existence which we can characterize as tao.

Tao admittedly is a metaphor nearly as inadequate as, say, energy. To argue whether we should call the universe's irreducible "breath" (simply an older image than energy, no real difference) form or thing, essence or existence, is - if I may steal a line from Calvin of comic-strip fame - to fail to appreciate the unimaginable wonder that it *is*. (pp.xv-xxiv)

What I find more interesting are those few - not revelations but, let us say - intuitions about truth which have undeniable potency. (Norwine, J., 1993, p.xxviii)

Since planning is never "value free", this study assumes that planning should unify with culture<sup>1</sup> and be in continuum with the

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<sup>1</sup> Marvin Harris (1987, p. 6), following the precedent set by Sir Edward Burnett Tylor (recognised as the founder of academic anthropology in the English-speaking world and the author of the first anthropology textbook by Harris), defines culture as "the learned, socially acquired traditions and life-styles of the members of a society, including their patterned, repetitive ways of thinking, feeling, and acting (i.e., behaving)." See also similar definitions by Anderson (1976, p. 36-37) and Haviland (1987, p.10). Barnouw (1963, p.4) also defines culture as "a way of life of a group of people, the configuration of all the more or less stereotyped patterns of learned behavior, which are handed down from one generation to the next through the means of language and imitation". And according to N.J. Adler (1991, p.15), "the cultural orientation of a society reflects the complex interaction of the values, attitudes, and behaviors displayed by its members".



values<sup>2</sup> of the people planners plans are supposed to serve. What is meant by "unified" with culture and "in continuum" with values "naturally flows and adapts with changes in time". It means that while planning should conform to "recent" contextual culture and values, it should not be aimed to objectify, reify and freeze this culture and values. Because, once the culture and values are defined, conceptualized, and reified to be attached as "rational" goals in planning, there is a danger that the goals become obsolete and the plan becomes repressive.

With this idea in mind, it seems contradictory that this research utilises a scientific approach that proceeds with problem definition, life-style conception, rational-objective-empirical survey, and alternatives investigation that may freeze the "reality" of culture and values. However, this is the "rule" of academic tradition that "should" be followed. As long as it is kept in mind that "objective" knowledge is an understanding of "frozen" facts, this rational research can capture transient facts of culture and values and provide momentary images and knowledge of reality that help the attainment of intuitive understanding<sup>3</sup>. In fact, intuitive understanding is the creative part of the proposed "culture-based" planning approach.

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<sup>2</sup> Values can be defined as abstract ideals, positive or negative, not tied to any specific attitude, object or situation, representing a person's (evaluative and normative) belief about ideal modes of conduct and ideal terminal goals (Rokeach, 1975, p.124). Thus, a personal value is an enduring belief that a specific mode of conduct (instrumental values) or end-state of existence (terminal values) is personally or socially preferable to alternative modes of conduct or end-states of existence (Rokeach, 1975, p.160).

<sup>3</sup> Yamaguchi (1969, pp. 145-148) describes that Henri Bergson offers two principal approaches to attain intuition: one is through the influence of accumulated research, and the other is through that of accumulated images. In order to attain intuition through accumulated research, we must study as much as possible all the results and contributions of the modern sciences, together with the abundant knowledge acquired through the introspection of personal psychological experiences. Then, in the process of fusion of this knowledge, the preconceived ideas or incorrect views of reality will be neutralized by each other in such a way that we can get ever closer to grasping the converging points to which this knowledge leads; that is to the true vision of reality, or intuition. This does not mean, however, that

In the Indonesian context, a culture-based planning approach should combine these rational and intuitive, subjective and objective approaches. The essence of Indonesian values is a mixture of Eastern and Western values, it is representing a belief<sup>4</sup> in harmony, a balance between spiritual and material development, a balance between rational judgment and intuitive appreciation<sup>5</sup>. Thus, this urban housing research in the city of Bandung, Indonesia, is directed by a belief that the rational comprehension and intuitive appreciation of life-style and housing choice in an urban area can provide "planners" an insight to the world of urban housing, which, in turn provides a clue (or images) about the types of appropriate housing to be encouraged for different

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intuition is the synthesis or generalization of all such knowledge. It is a transformation like "the transformation of the tension of the spring to the visible movements in the clock".

There are two kinds of images in the attainment of intuition through imagery. The first type of images are comparisons and metaphors which appeal to our personal experience. These images point directly to the intuition. With a different variety of images, we can get closer and closer to the true picture of intuition, as the accidental elements - in regard to the true picture of intuition - of each image neutralize one another. As is the case with the first approach, this approach is not sufficient without a plurality of images. The second type of image is a particular and unique type of image which, for example, a philosopher has immediately connected with his fundamental intuition of reality, from which intuition all his speculations and systematization derives. It is not intuition itself but something in between intuition and mental representation. For example, Berkeley's image of matter as a "thin transparent film" situated between man and God. The matter / film remains transparent as long as the philosophers leave it alone, and in that case God reveals Himself through it. But let the metaphysicians, or even common sense, meddle with it: immediately the film becomes dull, thick and opaque, and forms a screen because such words as Substance, Force or Energy slip behind it, settle there like a layer of dust, and hinder us from seeing God through the transparency. Unlike the first type of image, there can be just one image for one intuition.

<sup>4</sup> Beliefs are inferences made by an observer about reality. They can be descriptive, evaluative, or normative.

<sup>5</sup> The goal of harmony of material and spiritual development has been stated in Indonesian *GBHN* (Guide-lines of the State Policy) regarding the physical and spiritual nature of human being, but the balance between rational comprehension and intuitive appreciation is inferred here from the nature of human capability to grasp objective-material and subjective-spiritual reality.

household types. This "life-style or culture-based" planning is a new direction, within a planning paradigm, which seeks to accommodate plurality in values. It assumes that neither material (economic) development nor spiritual development is the single prime objective. Both of them are legitimate aspects of human development that may be differently emphasized by people according to their already internalized value orientations. Hence, the planners' bias may be mitigated if it cannot be eliminated.

The following sections delineate theoretical and practical issues that lead to this research, introduce the research objectives and the significance of research, outline the research method, and describe the organization of this thesis.

It should be noted that many Indonesian terms are used in the text. These are printed in italics and fully defined in Appendix A, Glossary.

### 1.1 Issues

If we appreciate, and wish to accommodate value differences, it is legitimate to assume that planners should have enough understanding about the nature of society, with its culture and its environment, that will be involved in the plan, the culturally appropriate method to implement the plan, and the values that should be incorporated in the plan. Actually, these three interrelated dimensions of required knowledge (about the object, the method or procedure, and the goal or ideology) have received much attention in the development of planning theory.

According to the existing literature, planning theories can be differentiated into three dimensions. The first one is substantive (explanatory) theory in planning that deals with the explanation of the nature of spatial interaction and urban process. Interest in substantive theory has expanded since the 1950s. The second theory is the procedural theory of planning that concerns planning processes and methods. This has received much academic discussion since the late 1960s. And lastly, since the 1970s greater attention has been shifted to

the values and ideology incorporated in the theory for planning. In a simplified way, we can describe the historical changes in the focus of planning theory as follows. First, the planner was primarily concerned with the objects of planning as physical-spatial objects and eager to know how they worked and why. The outcome is substantive planning theory. However, having gained sufficient understanding about the objects, the planner faced uncertainty with respect to the process or procedure of planning.

Secondly, following out of the first stage, attention was given to procedural planning theories. These "modern" planning theories, starting in 1960s, were inspired by cybernetics which was first identified and named by American mathematician and thinker, Nobert Weiner, in 1948. Then, the systematic planning approach was introduced by British proponents: Brian McLoughlin (1965), and George Chadwick (1966). It led to the development of rational comprehensive theory that was challenged for its "bounded rationality" (Friedmann, 1967 & 1987) and reduced to "disjointed incremental planning" (Lindbloom, 1959) or a "mixed scanning approach" (Etzioni, 1967). Still, there were objections to the rational approach that characterized procedural theory. Objections were directed to its tendency to relegate politics to technical judgements, to elevate facts relative to values (Davidoff and Reiner, 1962; Davidoff, 1965), to create abstractions rather than emphasise concrete issues, to preserve the status quo and social injustices, to centralize control and power (see Camhis, 1979; Thomas, 1979, Harvey, 1978). At the more detailed technical level, objections were concerned with the inadequacy of rational evaluation techniques, forecasting methods, the ability of the approach to deal with uncertainty and with public opinion, and many other issues.

The third wave started from the early seventies when much of the theoretical planning literature was concerned with finding alternatives to the rational decision model of procedural planning theory. Rather than focussing on one new approach, the result was a variety of alternative methodologies (Healey, McDougall and Thomas, 1982). These ranged from advocacy and pluralism (Davidoff, 1965), transactive and innovative (Harvey, 1978), radical practice of political community

(Friedmann, 1987) or neighborhood movement (Friedmann, 1989) or empowerment (Friedmann, 1992), and critical communication and argumentation (Forester, 1989).

In essence, most of the alternatives to "modern" planning theory tried to avoid the shortcoming of "modernity". The so-called postmodern movement is the general name of a common rejection of the "value-free", rational, mechanistic and rigid "tradition" of modernity. Its character is deconstructive (questioning conventional science)<sup>6</sup>, antifoundationalist (dispensing with universals as bases for truth), nondualistic (refusing the separation between subjectivity and objectivity, truth and opinion, fact and value), and encouraging of plurality and difference (Milroy, 1991, p.183). Regarding this movement, McGee (1991b, p.341) says that postmodernism helps to uncover the dominance of Eurocentrism but postmodernist theories offer no direction as to where to go from here. Nevertheless, the character of postmodernism is close to the character of Eastern philosophy that emphasizes intuition based on the unity between subject and object in "understanding" the life world<sup>7</sup>. Thus, postmodernism may build a bridge towards the synthesis of Eastern and Western philosophy.

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<sup>6</sup> The founding-father of Deconstruction, Jacques Derrida rejected any kind of science - or as he put it "scientificity" - on the grounds that it could not explain anything of interest about the human condition, or indeed about the world as a whole, for science rejects whatever we cannot experience directly with our senses, tests by scientific experiments and indeed regards such things as beyond our understanding and quite "unknowable" (Broadbent, 1991, p. 31.).

<sup>7</sup> In comparison between Eastern and Western intuition, Yamaguchi (1969, pp. 122-126) clarifies that Eastern intuition is not a sense-perception. Although a sense-perception is immediate vision, it differs from intuition since its object is outside the inner world. Nor is this intuition a direct understanding of the facts or situations of daily life as a separate object from subject. Nor is the Eastern intuition like that higher form of intuition which grasps first principles, such as the principle of gravity. However, the Eastern intuition is another kind of intuition related to mystical intuition. It is aesthetic intuition and its essential characteristic is its union with reality, or with the universe.

Before arriving at aesthetic intuition, the mind must be calm, in a state of quiet. There should be no preconceived ideas,

The above picture of theoretical development inspires that which was essentially overlooked in the earlier planning theories: that society and planner - the object and subject in planning - are not robots who are accurately rational, objective and mechanistic. Instead, they are human beings with different cultures and values, living in certain space and time with their uniquenesses. Their behavior is not merely based on their sensation but also intuition; not only based on thinking but also feeling<sup>8</sup>; not only biologically (physically) driven but also

---

uncontrollable imaginations, inordinate attachments, or distractions coming in from the external world, which would disturb the mind and grip the soul. When this state of quiet is attained, the internal force of the soul is gathered and stored up for its task of sustaining constant effort and of uniting the soul to all reality. Thus, in this state of mind, a certain emotion of sympathy with the life of the universe arises. This emotion gives spirit or life to the arts. It is the intensity of the artistic process, the pressure, under which the fusion of the inner and the outer worlds takes place.

This emotion, which may be called creative emotion, plays two important roles in the genesis of aesthetic union. One is to create interest in the mind which sustains a constant effort in this activity. The other role is that of helping to generate the intuition itself in a subject.

The soul, imbued with this intuition, discerns and devines reality not as something other than itself, according to the laws of speculative knowledge, but as inseparable from itself and from its emotion, and in truth as identified with itself. Having no conceptualized object, aesthetic intuition tends and extends to the infinite, towards all reality. It sees the whole universe even in singular existing thing - in its essential properties, in its existential relations with other beings and realities. That is why an artist can have union with the whole of the universe, even though his attention is focused on a singular concrete existence. What is grasped through intuition, therefore, is the mutual communication between subject and object or the fusion of the objective and subjective world.

This aesthetic intuition itself is only the first half of artistic activity. The aesthetic intuition which remains only in the realm of intuition is not an art. The production of the artistic work is just as essential to the artistic activity. The aesthetic intuition and the artistic production are, therefore, two essential phases of artistic activity.

<sup>8</sup> The idea of psychological distinction between sensations and intuitions, thinking and feeling, can be traced in Jung's (1971) "Psychological Types".

spiritually driven. Thus, instead of being rational-mechanistic, human behavior (and also planning behavior) is naturally intuitive-artistic (in rational statistical terms "probabilistic or stochastic"). The performance of any planning activity is quite influenced (not in a mechanistic sense term) by its context; not only the physical context, such as resources or technology, that was accounted for in rational planning theory, but also the non-physical context such as the personality and culture ('life style') of the people involved in the planning activity. Hence, a culture-based planning approach should incorporate the style of actors involved in planning activities. The incorporation of style means the inclusion of potential types of values, behaviors, processes and methods in the planning aggregate.

This dissertation research does not presume to accomplish the whole task of incorporating "life style" - as a part of culture - in the planning aggregate. Instead, it initiates a way to do so. It chooses to "scientifically" study "life style" coupled with urban housing problems in Indonesia, specifically in the city of Bandung.

The examination of urban housing issues in Southeast Asia and Indonesia (see Chapter II) reveals that the housing problem has been defined, through a modernization perspective, as a set of physical and economic problems. The housing problem is formulated as a problem of quantity (of decent houses) and affordability. Although the latest "self-help" approach replaces the concept of "housing as (consumption) product"<sup>9</sup> with the concept of "housing as (social-economic) process"<sup>10</sup>, this approach has no concern for the identification of values and preferences. Instead, its main doctrine is empowerment and resource mobilization with the hope for low-cost solutions.

The "culture-based" planning which seeks to accommodate plurality in housing values and preferences lacks information about differences in housing choices among different households. In the past,

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<sup>9</sup> The housing problem is to be solved through increasing housing production.

<sup>10</sup> The housing problem is to be solved through improving the housing process.

when people planned and built their own houses, they did not need this kind of information. But with growing urbanization and specialization, houses are more and more produced by a formal (modern) sector. The lack of information on housing preferences causes difficulties for developers to provide (to plan and design) appropriate housing. Hence, the housing problem is reformulated as a socio-cultural problem. From this point of view, the image of "socio-cultural demand" should be incorporated in the calculation of housing supply and in the creative planning and design of urban housing.

## 1.2 Research Objectives

The cultural issues of a planning approach - in this case in housing - yield a specific question whether housing preference, which reveals household's subjective socio-cultural values, can be identified and accommodated in the urban housing plan. This research as part of knowledge and image building in creative planning, is essentially done to answer this question. Thus, there are two goals in doing this research. The first direct but essential goal is theoretical: the intention to contribute to the development of a "culture-based" planning approach by constructing life-style theory and grasping the knowledge and images of life-style related housing required in the approach. The second goal is practical but cannot be attained directly by doing this research since this goal - the need to solve the urban housing problem in Indonesia especially through the improvement of appropriateness of formal housing supply - needs further artistic activity that can be performed only by skilled practitioners. This research provides inspiration that may help them.

These goals lead to the elaboration of life-style theory and two specific hypotheses to be tested in this research (see Section 3.2). The first hypothesis is that households that practice a similar "life style" have similar housing preferences. The second hypothesis is that life style, as operationally defined (see Section 3.3.3), is a better descriptor of housing preference than the single income variable commonly used in



housing prediction. In other words, the knowledge of a household's life style improves the accuracy of housing preference prediction.

### 1.3 Methodology and Scope

To test the two hypotheses, this research is designed primarily as survey research (with personal standardized interviews). However, quantitative results from survey data are not enough to describe and interpret life-style characteristics. Thus, this research also employs other data collection techniques such as; secondary data, photography, direct visual observation, interviews with decision makers, and informal interviews with some community leaders and households, in order to acquire qualitative understanding about the housing environment and the social and cultural background of households. In this case, the researcher's previous living experience (15 years) in the city of study really helps this qualitative understanding.

Thus, based on the operationalization of household's life style as the pattern of household's orientations as indicated by 16 household variables (see Section 3.3.3), a housing survey was conducted in the city of Bandung, the capital city of West Java Province, Indonesia. Three hundred and sixty seven households from 19 residential areas are statistically analyzed.

First, using Nonlinear Principal Component Analysis (PRINCALS), the 16 household variables are reduced to six dimensions which account for 88 percent of the variance of the original variables. Second, based on their similarity in these six dimensions, households are clustered (using Cluster Analysis) into six to ten groups. These groups of "similar" households are presumed to be life-style groups. Third, the consistency of households' membership in these life-style groups is examined using discriminant analysis. Since the households' memberships resulting from discriminant analysis are highly correlated with the earlier memberships produced by cluster analysis (the validity coefficients are between 0.854 to 0.91) we assume that the cluster analysis has effectively used information or variance provided by the six dimensions to segregate the households into life-style groups.

Fourth, accepting that the clusters are valid, chi-square analyses are done to test the first hypothesis about differences in housing preference related to life style; the clustering of cases into 6, 7, 8, 9, and 10 clusters is tested against the grouping of cases according to housing preferences (37 variables). Since the clustering of cases into 10 clusters shows better contingency with groupings based on housing preferences, these 10 clusters are used in the second hypothesis testing. The results show life-style segmentation is not always better than income segmentation in differentiating housing preferences. But income segmentation in sub-life-style groups provides much better predictive power than income segmentation in the whole sample. These testings confirm the utility of life-style segmentation for housing preference understanding.

Following is a description and interpretation of the ten life-style groups based on their household attributes and housing preferences. Intuitive appreciation helps to gain insight into value orientations of the life-style groups.

The last step is an analysis of the possibility of spatial juxtaposition of the identified life-style groups. The actual spatial coexistence of life-style-groups and the similarity of accessibility preferences among life-style groups - graphically presented using correspondence analysis - are compared. This comparison results in some alternatives of possible spatial juxtaposition of life-style groups.

#### 1.4 Significance of Research

The results of this research provide a basis for recommendations on two levels; theory and policy. First, the results indicate the potential of life-style theory to "explain" the differences in housing choice and thus help the appreciation of value differences. The research provides a basis for the development of (substantive, procedural and prescriptive) "culture-based" planning theory (see Section 6.2.1, p.281). Second, the results provide housing preference information useful for urban housing policy formulation. They inspire some possible policies - to accommodate and facilitate the existing life-

style trends or to direct them toward a desired goal - including a suggestive model for life-style integration (see Section 6.2.2, p.285).

### 1.5 Organisation

The following chapter gives a broader perspective of the urban housing problem in Indonesia. Chapter II describes urban housing issues in Southeast Asia and, more specifically, in Indonesia. This provides insight into the factors influencing Indonesian urban housing inadequacy and enables a reformulation of the housing problem into a specific question to be addressed in this research.

With the housing question and its background delineated, Chapter III proceeds with clarifying the research approach. First, it justifies the importance of the study. Then, a theoretical framework is introduced to explain the meaning and interrelationship of life style and housing phenomena, and to set up the hypotheses to be tested. Third, it deals with the research design; it establishes the method of measurement and classification of life-style groups, determines the unit of analysis and basis for life-style segmentation, clarifies the operational definition of household life style used in this research, outlines the statistical methodology, demarcates the scope of study, and explains the techniques of data collection.

Chapter IV describes the city of Bandung as the background setting of the sampled population. Three aspects are highlighted; the stages of urban growth and structure, the formation and characteristics of urban settlement, and the main socio-cultural backgrounds with the emphasis on Sundanese, Javanese and Chinese features.

Chapter V presents the research findings. First, it describes aspects of the survey including the distribution of the sample and the household and neighborhood characteristics. Second, it discusses the results of principal component analysis and life-style segmentation through cluster analysis and discriminant analysis. Also, it examines the association between life-style grouping and housing preference. Since the analysis shows some association between life-style grouping and housing preference, the third section compares the potential of life-style

segmentation and income segmentation for housing preference prediction. Fourth, the ten life-style groups that best differentiate housing preferences are described in detail. Each group is named according to a specific life style. Fifth, an exploration of spatial juxtaposition of life-style groups is conducted by examining the actual spatial coexistence of life-style groups and their similarities in accessibility priorities.

The last Chapter presents the conclusions and implications of the research. First, it provides assessment regarding the empirical results, research method and technique, theoretical validity, and practical application of life-style segmentation for projection. Second, it identifies the important contributions that can be derived from this research. It proposes a "life-style or culture-based" planning theory and illustrates some policy implications. Lastly, it provides some considerations for future operationalization and empirical application of the life-style concept in housing studies, and also suggests other research approaches and applications in other fields.