A Systems Approach to Natural Recreation Resource Management: A Case Study of Taiwan

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ABSTRACT

Owing to decades of accumulated economic achievement, the development of recreation resources has been a matter of urgency in Taiwan. Natural recreation resources mean different things for different people. A sound recreation management policy must take care of all requirements needed to operate the natural recreation resource protection, as well as effect their continued and profitable use. It is necessary to develop a theoretical and empirical, quantitative and humanistic framework for establishing a comprehensive recreation planning structure to maintain a balanced relationship between human needs and natural recreation resources.

The main purpose of this study is to develop and evaluate resource management strategy for the recreation area in Taiwan. Part One of this study is devoted to the theoretical aspects of formulation methodology. To this end existing planning methods and optimisation techniques were examined. It concluded that a recommended method which includes a decision model by combining the planning technique of Landscape Ecology Planning Method with Multiple Objective Programming technique, in conjunction with recreation carrying capacity and cost-benefit analysis as planning concepts should be introduced for planning and managing the recreation area.

In order to illustrate the use of the method, the planning and management of a recreation area in Taiwan was considered as a case study in Part Two of this study. A preliminary planning structure of the recreation area is formulated on the basis of Landscape Ecology Planning Method. Several land use alternatives were evaluated through the decision model to achieve satisfactory results within the given planning and managing environment of conflicting socio-economic and ecological objectives. It can help planner and manager to judge which management strategy could be approved for further study.

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PART ONE : THEORY

CHAPTER 1

INTRODUCTION

Recreation is the activities of humans during leisure time, when undertaking amusement and self-satisfaction. Whereas natural recreation resources are the physical-environmental elements or phenomena in nature for satisfying the recreation demands of human beings.

The development of the recreation industry not only represents the progress of a national construction enterprise, but also reflects the living standard of the people as a whole. Taiwan island itself covers an area of only a little more than 36,000 km^2. But for its special geographic environment and favourable climate, this island has an abundance of natural recreation resources. Among these, some have been listed as international-class tourism resources. In addition, Taiwan, with its agriculturally-based native history presents a special farmscape of different land use in the countryside. It makes the rural environment quite different with the urban environment. This not only enables the undeveloped countryside to become an important factor in stablishing the ecological balance of the island environment, but also allows many rural areas to become the best places for holiday excursions.

On the other hand, owing to decades of accumulated economic achievement, not only has the consumption style of the Chinese people of Taiwan changed, but also leisure time is different from the past. People no longer save so much of their surplus money as bank deposits to earn interest as in the past, but invest it in other business or consume it on leisure activities. On weekends or holidays people generally do not work endlessly for sustaining life as they did in the past, but go out of the home for leisure activities. Today, because the recreation areas are not adequate to accommodate such a large amount of visitors, and because of other factors, many people are compelled to go abroad for several days or weeks of travel.

According to the prediction made by the Urban and Housing Development Department, Council for Economic Planning and Development, Executive Yuan of Taiwan,[(1)] the total participants in recreation activities in Taiwan will reach six-hundred million in the year 2001. On average, each resident above the age of 12 will have a yearly participation-frequency in tourist activity of 31. This verifies Abraham Maslow's "demand hierarchy" theory.[(2)] People of Taiwan stand now at the highest level of the hierarchy of psychological demand. This change necessitates the development of recreation resource on this island to be treated as a matter of urgency.

Although the established recreation areas are significant, the recreation resources have not been well managed. One of the greatest causes is illogical planning and management of these resources.

As the stand-point between the social demand and the environment conservation are often different to each other, the opinions of each professional are different and yet imperfect. Especially in recent years, because of international recognition of environment problems, scholars and academic specialists are urgently directly their effort to the study of environmental problems.[3][4] Among them, those using mathematical methods for environmental planning are not the least in number.[5][6][7] But for natural recreation resource management, studies using mathematical methods are rare.[8]

The purpose of this study is to develop and evaluate resource management strategy with special reference to the recreation area in Taiwan. It is also expected to be applicable to other countries after modification to suit their local conditions.

The study contains two major parts (Figure 1.1). Part one is the establishment of theory and method which includes the introduction of the study structure, a general discussion of the natural recreation resource management problems of Taiwan and the literature review of the existing planning methods. Concept of recreation carrying capacity and its measurement are discussed while the reasons for the needs of a more precise approach to manage the natural recreation resource and the reasons for choosing multiobjective programming are given. The theoretical part of the study is concluded by a description of the recommended method for the planning and management of natural recreation resource. Concept and content of this part are discussed in more detail.

A preliminary survey of natural recreation resource management shows that it has obtained a certain degree of positive results in recent decades in Taiwan. In viewing the present situation of each recreation area, it is not hard to discover that there are many problems existing. Among these poor planning and management are the major issues which need to be evaluated and improved. Therefore, a discussion of the evolving situation of the recreation practices and problems on various levels in Taiwan is made through an analysis of literature review in Chapter Two, so as to work out a solution as a basis for reference.

Several existing methods have been adopted in the planning and management of natural recreation resources. They are generally classified into two groups: sociological and ecological. Planning methods based on sociology consider that humans undertake recreation activities for the satisfaction of recreational psychological demands. While planning methods based on ecology regard natural recreation resources as possessing characteristics of diversity, uniqueness and usability. Most of these characteristics reflect the vulnerability of nature. They need to be protected and preserved.

Both sociological and ecological methods intend to obtain rational use of recreation resources and concurrently to balance human needs with ecology. But neither of the two is comprehensive. In Chapter Three, available recreation resource planning methods are analysed from the sociological and ecological points of view. Their advantages and disadvantages are evaluated through the criteria established by this study as a basis for the formulation of the recommended method.

Special emphasis is placed on recreation carrying capacity which is one of the planning factors to raise both recreational and environmental quality. In Chapter Four, theory and affecting factors of recreation carrying capacity are discussed and the methods of measuring recreation carrying capacity are evaluated, to give sociological and ecological quantified data, so that the planning result is more persuasive.

Management of recreation resources usually has multiple purposes. These purposes often conflict with each other. The situation cannot be solved with a single-purpose mathematic programme, but must have application to multiobjective programming. The problem of multiobjective programming to be solved is how to satisfy many value-conflicting multiple purposes at the same time under limited resources of the system.[9] In multipurpose problems an optimum nondominated solution exists. This indicates that when an objective function decreases, the other objectives relatively increase.

Multiobjective programming has been applied to natural resource planning and management for years. However, practical causes of such programming being applied to natural recreation resources are very rare. In Chapter Five, the feasibility of a systematic method and the need for multiobjective decision analysis as well as its application on recreation resource management are discussed. The nature of multiobjective linear programming and the operation flow chart are also examined.

In Chapter Six, a model of natural recreation resource management is established by making use of the combination of Landscape Ecology Planning Method and Multiobjective Linear Programming. Factors considered for the establishment of the model and the assumptions and steps of the model are presented.

Part two of the study is the application of the recommended method to illustrate the use of the method, and the planning and management of natural recreation resource in a recreation area of Taiwan is considered as a case study which contains three chapters. In Chapter Seven, a preliminary planning and management plan of Ta-keng Scenic Area is carried out with the planning process of the recommended method developed by this study.

In Chapter Eight, measurement of social-psychological and physical-ecological carrying capacities of recreation spots of the Scenic Area and its results are presented. Since the basic data required by the recommended method are not available, it is necessary to conduct a field survey and observation of the tourists' perception of tolerance and perception of crowdedness for each recreation spot of the study area. Then it applies Analytic Hierarchy Process method (AHP) to measure the physical-ecological carrying capacity. Detail of the survey method used and an analysis of the survey results are presented.

The formulation of phasing plan and cash flow schedule and the evaluation of land use plan for the future development of the Scenic Area are described in Chapter Nine. An analysis of cost and benefit and the estimation of net present value for each recreation spot of the study area are given. The parameters required for computation are presented and then the computation are carried out by using computer programme VIG.[10] Through repeated Pareto Race, several land-use plans are generated. which an optimumal nondominated solution exists to satisfy three management objectives of natural recreation resources. Then, a comparison is carried out by measuring their distances from a reference point. A "satisfactory" land use plan of Ta-keng Scenic Area can be ascertained.

The last Chapter is concluded by a summary of theoretical concepts and the discussion of the recommended method, so that the feasibility of the recommended method is justified. Areas for advanced study are suggested for subsequent researchers for study in the Chapter.

It is believed that benefits of the study can be expected as follows:

1. By reviewing the natural recreation resource management problems of Taiwan, the study furnishes a reference for studying and formulating the development and use of recreation resources, either by the relevant government agencies or by private development organisations.
2. By establishing a method which not only considers the three major factors - sociological, ecological and economic, but brings mathematical programming into a comprehensive planning structure, the study can be used as reference by central and local governments and private enterprise for development investment.
3. By means of the established recreation resource management model, the recreation areas which have the most potential can be developed to their best use.

4. This study should be valuable as a reference to decision makers who have different viewpoints in formulating management policies.

5. Through the survey and analysis of the study area, a reference for planning and managing of the area, or other similar areas is provided.

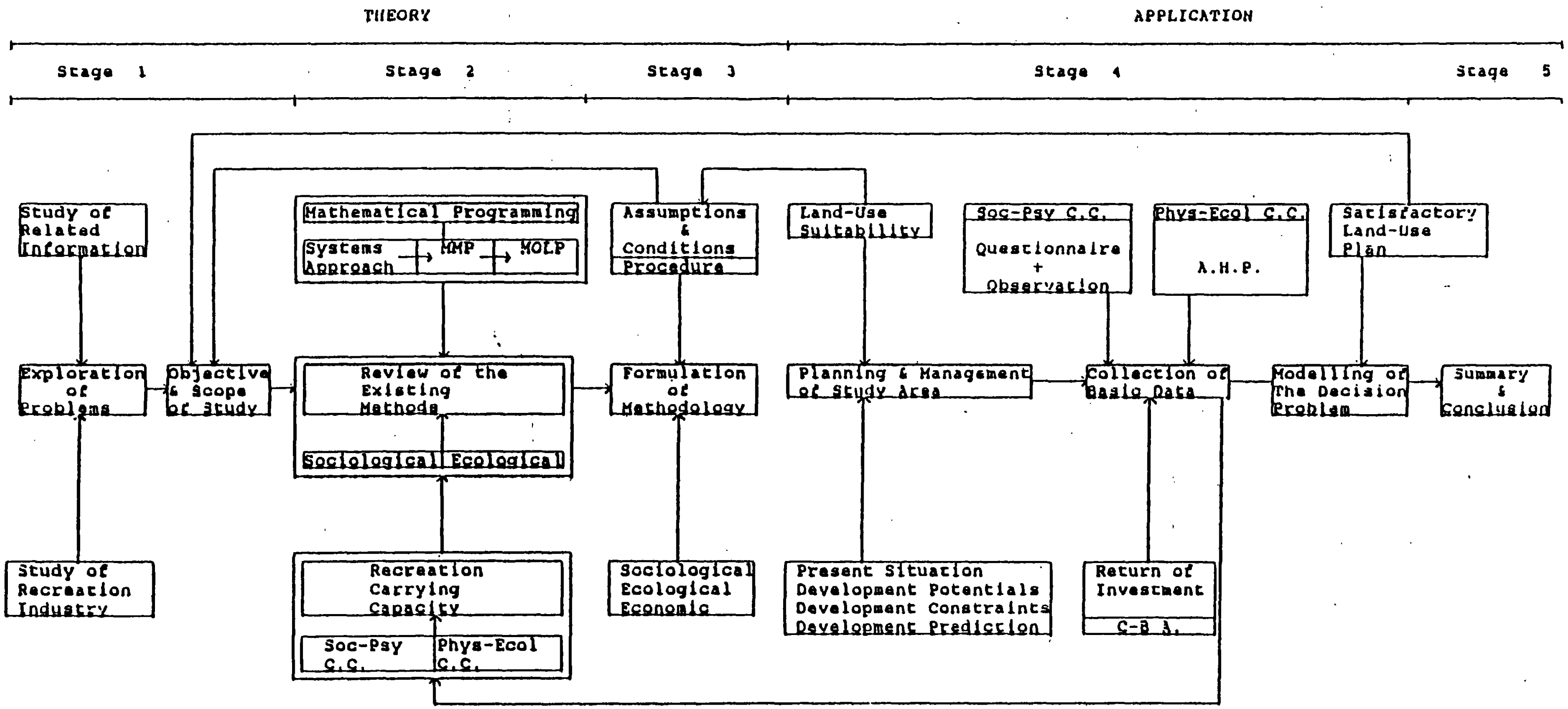


Figure 1.1 Flow Chart of Research Methodology.

REFERENCES

1. Taiwan, Urban and Housing Development Department, Council for Economic planning and Development, Executive Yuan : "A Study on the Sightseeing System of Taiwan". (in Chinese), Taipei, ROC, 1983, pp. 88-97.

2. Torkidsen, G. : "Leisure and Recreation Management". E & F. N. Spon Ltd., London, England, 1983, p.211.

3. Perry, J. Brown : "Planning for the Use of Recreation Resources". International Symposium on Landscape and Recreational Planning,Taipei, ROC, 1985. pp. 1-20.

4. Stankey, G. H., et al., : "The Limits of Acceptable Change System for Wilderness Planning". U.S. Forest Service Gen. Tech. Report, INT-176, U.S. Dept. of Agri. Intermountain Forest and Range Exp. Sta. Ogden, UT., U.S.A., 1974, pp. 7-11.

5. Haimes, Y. Y., et al., : "Multiobjective in Water Resource Systems Analysis : The Surrogate Worth Trade-off Method". Water Resources Research, Vol.10, No.4, American Geophysical Union, Washington, D.C., U.S.A., 1974, pp.615-624.

6. Goicoechea, A., et al., : "Multiobjective Decision Analysis with Engineering and Business Application". John wiley, New York, U.S.A., 1982, pp. 409-412.

7. Ahlfeld, D. P., et al., : "Contaminated Groundwater Remediation Decision Using Simulation, Optimization, and Sensitivity Theory". Water Resources Research, Vol.24, No.3, American Geophysical Union, Washington, D.C., U.S.A., 1988, pp. 443-452.

8. Antle, L. G. : "Recreation at the McClelan-Kerr Arkansa River Navigation System". Water Resources Bulletin, Vol.15, No.5, American Water Resources Association, Bethesda, U.S.A., 1979, pp. 25-38.

9. Ditto 6, pp.9-15

10. Korhonen, P. and Laakso, J. : "A Visual Interactive

Method for Solving the Multiple Criteria Problem". European Journal of Operational Research, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1986, pp.277-287.

CHAPTER 2

RECREATION RESOURCE MANAGEMENT PROBLEMS OF TAIWAN

2.1 Introduction

According to the demands hierarchy theory of Abraham Maslow, the demand levels of humans can be arranged from bottom upward into five levels: physiology, safety, belongingness and love, esteem and self-actualisation.[1] They are formed into a pyramid. (Fig. 2.1) Only after the

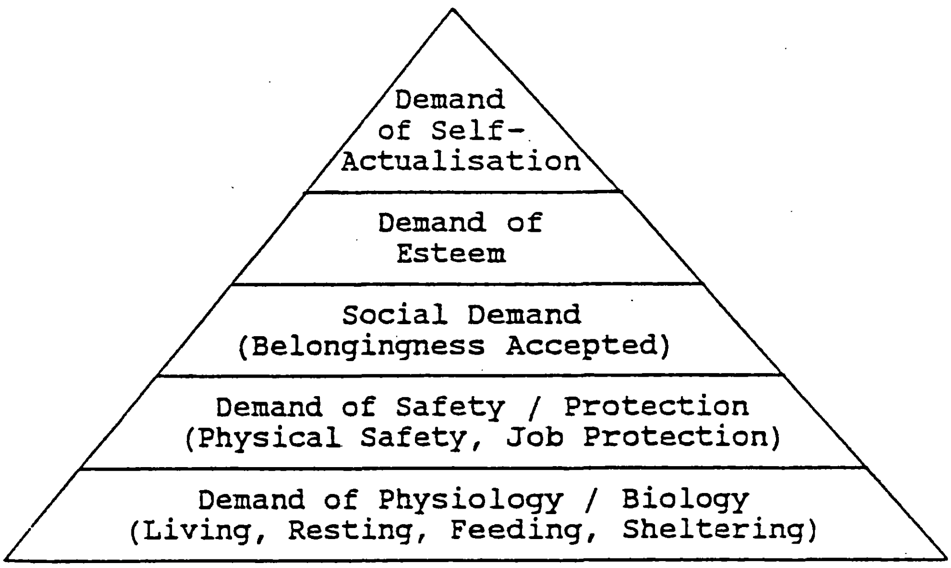


Figure 2.1. Maslow's Demand Hierarchy Structure (Source: Torkildsen, 1983)

satisfaction of the lower level basic physiological needs, does pursuance of the upper level mental-demand satisfaction come into being. Recreation belongs to the uppermost level of self-actualisation. Thus in more economically developed areas, after basic physiological-needs have been fully satisfied, the inclination exists for the satisfaction of mental-demand for tourist recreation.

Owing to different recreation motives, tourists will choose a recreation environment which meets their demands. The recreation environment will provide different recreation opportunities in accordance with the recreation resources available.

A recreation resource is that natural environment which makes up a tourist's recreation environment. A recreation resource has three attributes:(2) (1) it has value for sightseeing, ecology and culture, (2) it can be used for tourism and recreation, and (3) for the use of tourism and recreation, it will not negatively affect the resource value of the above two.

Taiwan, superb in natural environment, variant in terrain features, abundant in natural resources and mild in climate, has become a famous international tourist destination. Additionally, because of the rapid growth of the Taiwan economy in recent years, the society of Taiwan has been rapidly changing. Proper recreation activities for leisure time are becoming an important part of the daily life of more and more people. In recent years, the government has been taking great account of the planning and development of recreation resources. It has not only listed recreation resource planning as the main focus in the "Taiwan Comprehensive Development Plan" and in every regional plan, but it has also declared it one of the important administrative concerns in the years to come. However, at the same time, this has caused a lot of recreation resource management problems. Therefore, this chapter discusses development of the recreation industry in Taiwan. It also discusses recreation resource management problems. Based on those problems a rational solution is worked out, to be used as the basis for defining the scope of the study.

2.2 Recreation Resource Development

2.2.1 Factors Affecting Demand for Recreation

Based on the current situation in Taiwan, the main factors affecting demand for recreation activities include those factors associated with socio-economic development and those of individual personal characteristics. The former belong to external variables that affect entire national or regional recreation demands. The latter belong to internal variables that influence individuals to select types of recreation activities.

In Taiwan the factors affecting recreation demand are briefly stated as follows.

1. Urbanising Population

In recent years the industries of Taiwan have advanced and expanded tremendously. As a result, the economic system has been transformed from an agricultural to an industrial basis. Also, a large population has migrated from rural areas to urban areas. For example, a total of 303 planned urban areas existed in 1979. This increased to

417 planned urban areas in 1988. During the same period the urban population increased from 67.2% to 75.8% of the total population. Since the demand for recreation is much higher for urbanites than for rural dwellers, the increase in the urban to rural ratio has brought more demands for recreation.

2. Fluctuation of Recreation Population

According to published reports,[3][4][5] in 1972 there were 6,886,079 person visits to recreation areas in Taiwan. The total person visits jumped to 28,322,796 in 1979, and again jumped to 31,749,797 in 1989. Except in 1958, when the Kinmen island artillery bombardment was taking place and in 1974 a year of oil crisis, the number of foreign visitors has grown steadily since the end of World War II. However, reports show[6] that the number of both domestic and foreign tourists decreased to 29,651,272 in 1990. The same report indicates that one of the reasons is the poor planning and management for recreation areas. Undoubtedly, the recreation industry will become more important in the future.

3. Increased Leisure Time

The time expanditure of a person can be classified into those hours necessary for life maintenance, for work and for relaxation and recreation. The average Taiwanese in 1974, in the 168 hours in a week, allocated 74 hours for life maintenance, 50 hours for work, and the remaining

44 hours for leisure time.[7] Changes in time allocation have been forecast for the year of 2001 as follows: life maintenance will reduce to 70 hours, work will reduce to 44 hours, but leisure time will increase to 54 hours per week. The main reason for the changes is that manual labour will be replaced by high efficiency, labour-saving machinery. Consequently, work hours will shorten and holidays and vacations will be increased by industry or by government regulation. Also, due to greater longevity there will be more retired persons having more leisure time. This will raise the proportion of leisure hours still higher.

4. Improvement in Transportation Facilities

Transportation systems have a direct influence on the type of recreation activities. In recent years the government has constructed several important road systems and facilities, such as the Middle, East and West Cross-Island Highways; the North-South Motorway; as well as a second motorway and South and East Cross Railway now under construction. All of them were built primarily for economic purposes, but they greatly in help the accessibility of most recreation areas. As for vehicle ownership, there were only 36.82 cars per 1,000 people in 1981. By 1989, it had increased to 123.69 cars per 1,000 people. During the same period, the number of motorbikes increased from 259.39 per 1,000 people to 369.42 per 1,000 people.[8] As the economy grows the rate of vehicles owned by people also increases. As the transportation system advances the accessibility of most recreation areas improves and the demand for recreation also increases.

5. Average Income Increases

Earned income not disposed or otherwise is saved. Excluding that used in purchasing the necessities for survival and living, the remainder of the income is available to be consumed in recreation activities. Average annual income per person in Taiwan (using 1976 NT$ value) was $13,601 in 1960; it was $50,733 in 1981. Of this only 5.14% was spent for recreational, educational and cultural activities in 1960 but it increased to 13.37% in 1981. In view of the facts that average per person income was more than U.S.$ 8,815 in 1991[9] and spending for recreational and cultural activities has kept increasing, the amount of disposable income for recreation is now quite large. The demand for recreation opportunities will be much more pressing in the future.

2.2.2 Classification of Recreation Resource Types

The purposes of recreation resource classification are (1) to provide basic information to management; and (2) to achieve a balance between recreation demands and resource conservation.

There are several classifications of recreation resources which reflect different viewpoints. The U.S. Outdoor Recreation Resource Research Commission (1962)[10] classified recreation resources based on management objectives: (1) high-density recreation area, (2) general outdoor recreation area, (3) natural environmental area, (4) unique natural area, (5) primitive area and (6) historical and cultural site.

Clawson, et al. (1966)[11] classified these types: (1) user-oriented, (2) resource-based and (3) intermediated.

Dasman (1973)[12] classified reservation areas according to environmental protection measures: (1) anthropological, (2) historical and archaeological, (3) natural environment and (4) multiple purpose.

Coppock, Duffield and Sewell (1974)[13] proposed a classification of recreation activities based on altitude: (1) on-ground, (2) water-based, (3) landscape, (4) land-use type and (5) ecology type.

Chao Ming Chen (1976)[14] also categorised scenic areas according to altitude: (1) seacoast, (2) steppe and plain, (3) hilly, (4) outskirt mountainous, (5) remote mountainous and (6) lofty mountainous.

In Japan,[15] recreation resources are classified according to scenic values:

(1) national parks

(2) nationally recognised parks

(3) city and county parks

In Australia,[16] New South Wales National Park and the Wilderness Conservation Bureau categorised recreation areas according to conservation measures: (1) national parks, (2) nature reserves, (3) historic sites, (4) aboriginal places (5) protected archaeological areas, (6) wildlife refuges and (7) game reserves.

The Urban and Housing Development Department, Councial for Economic Planning and Development of Taiwan (1983)[17] based its classification on geographical and environmental characteristics:

(1) seashores and coasts

(2) lakes and reservoirs

(3) rivers and valleys

(4) forests

(5) grasslands

(6) special scenic areas

(7) anthropological and archaeological areas

(8) artificial outdoor recreation areas

(9) historical remains and buildings

(10) rural scenic area

(11) hills and mountains

(12) others, such as wild animals, and river estuaries

and deltas.

There are about 325 frequently visited recreation areas in Taiwan. Each area has its unique recreation resources. It is proposed in this study the following classification which is based on the integration of environmental factors, resource characteristics and acts and codes:

1. Scenic Recreation Areas : These areas are mainly used for recreation and supplemented with conservation and other purposes. These areas are subdivided into the following types:

(1) General Scenic Recreation Areas : These areas include special scenic areas, forest recreation areas, sea water bathing areas, seacoast parks and other scenic areas. Suitable recreation activities are numerous. Special scenic areas and other scenic areas may combine their resource characteristics to offer diverse recreation activities.

(2) Special Scenic Recreation Areas : These areas include zoos, botanical gardens, golf courses, aquariums and ocean parks. The main recreation activities offered are nature trails, relaxation, golf and in-water activities.

(3) Roadside Landscape Recreation Areas : These areas include scenic roads and hiking trail systems. The main activities offered are hiking, mountain climbing, exploring nature, relaxation and appreciating natural scenery.

2. National Parks and Equivalent Reserves : This category has conservation as the primary objective and recreation as secondary. It is subdivided into the following four types:

(1) National Parks : A park may be subdivided into several administrative zones and offer different recreation activities. It provides multiple recreation activities.

(2) Nature Reserves : Suitable only for exploring nature.

(3) Wildlife Reserves : Suitable only for exploring nature.

(4) Other Preservation Areas : Also only suitable for nature exploration.

3. Historical Ruins : The main purpose is to preserve relics and historical ruins; recreation is secondary. It is subdivided into the following:

(1) Relics : The main activity is visiting historical ruins.

(2) Temples and Shrines : Activities include visiting temples and shrines, resting and appreciating the scenery.

4. Production Farms : Farm production activities are the main recreation source. This is a new field in recreation and includes visiting pastures, orchards, horticulture gardens, tea plantations and even farm villages.

2.2.3 <u>Recreation Demand and Supply Situations</u>

According to the prediction of the Residence and Urban

Development Office of the Economic Development Committee, Executive Yuan,(7) the projected annual growth rate of person visits to recreation areas in Taiwan from 1981 to 2001 is 16.92%. The average number of visits by a resident older than 12 years old will jump from 10 visits to 31 visits a year during the same period. It also indicates that a total of 160,000 ha of land area is needed in 2001.

In terms of supply, among legally existing recreation areas of all types, national parks have the largest hectarage. The four national parks occupy more than 240,000 ha which marked a milestone in recreation development in Taiwan. Other mountain areas such as Hsueh Shan and Ta-Pa-Chien Shan possess rich recreation resources which offer potentially valuable multiple recreation activities.

The other recreation areas, such as special scenic areas and forest recreation areas, are of smaller scale and variable size. Except for a few areas, most are greater than 25 ha. Perhaps the Northeast Corner Coast which has more than 10,000 ha is the largest. The next in rank is Wu-Shan- Tou Reservoir with 7,000 ha, then Tseng-Wen Reservoir with 5,000 ha. The smallest one is Tien-Hsing (18) with 15 ha. It is predicted that in 2001, apart from national parks in which recreation resources are limited, used land area for recreation will total about 80,000 ha. This indicates that more land is needed to develop for recreation. As natural recreation resources are limited with characteristics of nonrenewability and nonrestorability, it is necessary to obtain a rational balance between development and conservation of the resources.

2.3 Problems of Managing Recreation Resource

Recreation resource management is the most important issue in developing and conserving natural resources. The adequacy of management is the key to success or failure of the recreation resource planning. Nevertheless, resource management is involved in a complicated array of political, economic, social, planning, development and conservation problems. Having a small land base with an overcrowded population, it is necessary for Taiwan to maximise profits from limited recreation resources. In this section, problems currently encountered in recreation resource management are discussed.

1. Insufficient Data Base and Analyses

In general, recreation activities occur locally and seasonally. However, the basic surveys that have been carried out in the part on recreation areas have had little accuracy, for they have not considered stratification by locality and time of year. Furthermore, the percentage of people who participate in recreation activities, the average person's life style and social backgrounds of tourists, etc., have not been analysed sufficiently. Consequently, after the official inauguration of a recreation area, it happens that in peak seasons the number of visitors far exceed the capacity of the recreation facilities. On the other hand, in a low season the number of visitors are far fewer than the expected minimum, so that it is impossible to make ends meet.

2. Planning Has Become a Game of Numbers

Quantitative planning technique has been gradually adopted in planning method. However, without a sound theoretical base and reliable data bases has been criticised as simply the manipulation of numbers.

3. Ignoring Carrying Capacity Factors

Since the opening of a recreation area, many environmental and ecological problems have been generated as the result of neglecting carrying capacity at the planning stage. For example, increased soil compaction due to visitors trampling on it has seriously damaged ground cover vegetation. Road and recreation facility construction has affected local soil and water conservation. Finally, the logging of trees and increased noise has adversely affected wildlife habitat and significantly lowered recreation environmental quality.

4. Ignoring Recreation Resource Evaluation

In recreation planning and development resource evaluation has been ignored. It not only has prohibited an effective utilisation of the recreation resource, but it also has reduced the valuable recreation experience of tourists.

5. Lack of a Comprehensive and Practicable Recreation Resource Management Plan

Presently, recreation planning puts more emphasis on technological development and less emphasis on long-range planning such as managing resources after the development phase. Hence it is as yet impossible to exhibit the superiority of any far-sighted plans.

6. Lack of Professional Planning Knowledge

Those responsible for recreation area development plans are usually engineers of general training who lack knowledge about conservation. Due to the shortage of environmental science professionals, the development of an area in fact creates more environmental pollution and aesthetic distractions.

7. Lack of Alternatives in the Development Plan

Recreation development plans often lack attention to alternatives. This not only reduces flexibility but also presents comparisons from being made of development and conservation costs between alternative plans.

8. Lack of an Environmental Monitoring System

Lacking a sound enviromental monitoring system and effective environmental protection laws, it is impossible to prevent environmental damage during or after the development of a recreation area. It is also difficult to perform the right treatment at the right time on conservation problems under these circumstances.

2.4 Conclusion

Owing to the influence of socioeconomic factors, the demand for recreation space in Taiwan will inexorably increase in the future. According to this prediction, the total person visits to recreation areas will increase. Although the planned and already developed recreation areas are relatively spacious, many adverse factors have affected efficient use. These problems may cause unrecoverable destruction. Hence, it is necessary to prepare thorough plans for development and management as well as protection and conservation which may achieve the desired objectives and make effective use of recreation resources in order to maximise tourist satisfaction.

The land base of Taiwan is limited. Under pressure of expanding recreation demand, the most urgent task facing Taiwan today is how to create an optimum land use. In the next chapter, planning theories and methodologies are reviewed and discussed. It derives an optimum recreation planning system.

REFERENCES

1. Torkildsen, G, : "Leisure and Recreation Management". E & F.N. Spon Ltd., London, England, 1983, p. 211.

2. Chen, Shui Yuan : "Introduction to Tourism and Recreation Resource Planning". (in Chinese), Ta Li Publishers, Taipei, ROC, 1982, p.30.

3. Taiwan, Tourism Bureau, Ministry of Communications : "Monthly Report on Tourism". (in Chinese), Taipei, ROC, February 1973, pp. 20-23.

4. Taiwan, Tourism Bureau, Ministry of Communications : "Monthly Report on Tourism". (in Chinese), Taipei, ROC, February 1981, pp. 20-21.

5. Taiwan, Tourism Bureau, Ministry of Communications : "Monthly Report on Tourism". (in Chinese), Taipei, ROC, February 1990, pp. 26-27.

6. Taiwan, Tourism Bureau, Ministry of Communications : "Monthly Report on Tourism". (in Chinese), Taipei, ROC, March 1991, pp. 29-37.

7. Taiwan, Urban and Housing Development Department, Council for Economic planning and Development, Exective Yuen : "A Study on the Sightseeing System of Taiwan". (in Chinese), Taipei, ROC, 1983, pp. 88-97.

8. Taiwan, Tourism Bureau, Ministry of Communications : "Monthly Statistics Report on Transportation". (in Chinese), Taipei, ROC, September 1989, p. 27.

9. Taiwan, Executive Yuen : "Seasonal Statistics Report on People Economic". Taipei, ROC, December 1991, p. 31.

10. The U.S. Outdoor Recreation Resource Research Commission : "Outdoor Recreation for America". U.S. Government Printing Office, Washington, D.C., 1962, pp. 15-18.

11. Clawson, M. & Knetsch, J.L. : "Economics of Outdoor Recreation". The Johns Hopkins Press, U.S.A., 1966,

pp.10-17.

12. Dasman, F.J. : "A Generalized Trip Distribution Model". J. of Regional Science, Vol.13, No.2, The Regional Science Research Institute, U.S.A., 1973, pp. 23-24.

13. Cooper, C.P. : "Spatical and Temperal Patterns of Tourist Behaviour". Regional Studies, Vol. 15, No. 5, Carfax Publishing Company, Oxfordshire, U.K., 1981, pp. 359-371.

14. Chen, Chao Ming : "A Survey and Analysis for Forestry Recreation Resources of Taiwan". (in Chinese), A Research Report of National Taiwan Univ., Taipei, ROC, 1976, p. 91.

15. Ibid 14. p. 88.

16. Ibid 14. p. 89.

17. Taiwan, Urban and Housing Development Department, Council for Economic Planning and Development : "A Study on Tourism and Recreation System of Taiwan". (in Chinese), Taipei, ROC, 1983, pp. 38-39.

18. Taiwan, Tourism Bureau, Ministry of Communications : "A Study on Recreation System of Taiwan". (in Chinese), Taiwan, ROC, 1988, p.126.

CHAPTER 3

REVIEW OF THE EXISTING METHODS

3.1 Introduction

As mentioned above, the most directly prescriptive space form is based on the land-use plan of a recreation area in terms of the management of recreation resource. Therefore, when the existing methods are concerned environmental planning methods and concepts which are always adopted in the planning of a recreation area are discussed in this study.

Land use planning is a continuous process of researching, analysing and synthesising. It consists of surveys of land resource status, potentials and limitations; analyses of future social needs and aspirations as well as their interrelationships; and, based on those investigations and analyses, to propose alternative plans, evaluate them and recommend the best plan for implementation. After implementation, results should be reviewed and compared with alternative plans. This should be repeated perpetually so that any changes in environmental conditions, technology, human demands and other important factors can be taken into planning consideration. Recreation resource management can be defined as taking recreation resources as a planning theme, incorporating land capability and suitability to classify lands into proper usages, so that the demands of tourists can be pursued.

Since the early 1960s, several studies on recreation resource planning have been published. There is extensive literature which explores theories and methods of recreation resources planning. However, most of it discuss it subjectively. Environmental protectionists, for example, advocate recreation planning based on environmental conservation. Earlier recreation planning, however, accommodated the psychological demands of tourists. In this chapter the discussion is made from the sociological and ecological points of view, to provide basic references for planning of rational recreation systems in the future.

3.2 <u>Planning Methods Based on Sociology</u>

The nineteenth century scholar, Moritz Latarus, considered that leisure time provides physical and mental relaxation and removes fatigue. It is a human basic necessity.(1) Driver and Tocher(2) also recognised that "Recreation is a human experience. This experience is pursued by human inner demand which is voluntary during unpressured periods of time". In 1966, Wager proposed three prerequisites for recreation management and planning: (1) the objective of recreation management is to provide human benefits and welfare; (2) by participating in recreation activities, tourists obtain recreation satisfaction and positive experiences; and (3) the quality of recreation may be different due to the degree of tourist satisfaction.

It is apparent that recreation activities are engaged in because they are part of the basic demands of society. The request for good recreational environments usually depends on the tourist's interests, expectations and ability to appreciate. Therefore, from the viewpoint of sociology, the tourist's ideas and behaviour are the most important factors in planning. They also play the most important role in the management of recreation resources.

Since the 1950s, recreation planning has developed in two directions.[3] One has shifted the focus from site-oriented planning to a local and regional orientation. The other has shifted from monofunctional to multipurpose planning. The latter accommodates different types of land use on the same piece of land. This trend makes recreation planning more complicated because new recreational functions may be added and require a different planning structure.

3.2.1 Planning with Public Participation

Public participation in planning is a current trend that started in the 1960s. It has two major objectives: one is to involve government and people together, have them communicate or exchange their opinions, as well as to increase the reliability of the planning. The other objective is to promote a democratic way of achieving social and political purposes.

In the United States,[(4)] for example, the Wilderness Act of 1964 requires that federal agencies in charge of national parks should hold public hearings before proposing wilderness area plans. The (U.S.) National Environment Policy Act (NEPA) of 1969 has increased involvement in management of federal lands. NEPA requires U.S. government officials to be responsible to the public by not only making an Environmental Impact Statement public in advance, but also the statement should include the public's suggestions and recommendations and explain whatever actions are taken by the government agency. Otherwise, any interested parties neglected can sue or file a written complaint to a Federal Court.

According to degree of public involvement, planning with public participation is classified into these five categories: advertisement, persuasion, inquiry, partnership and public decision. The public inquiry mode was formerly adopted, but the government and the public seemed never to completely trust each other. As a result, this created unnecessary resistance. The best way would seem to be to leave it entirely to public decision, but in reality it is almost impossible to carry out that mission. Consequently, the partnership mode is advocated more now.

There are three steps in executing the partnership mode: (1) information exchange phase--give plenty of information to the public to study solicit and make suggestions; (2) idea examination phase--propose the government idea and give it to the public, committee or experts to inspect and criticise; and (3) plan evaluation phase--evaluate alternative plans and select the most beneficial and least harmful plan. This provides opportunities for learning from each side.

Although it is a time consuming process, the results are always the most satisfactory. The process is summarised in the flow chart below: (Fig. 3.1)

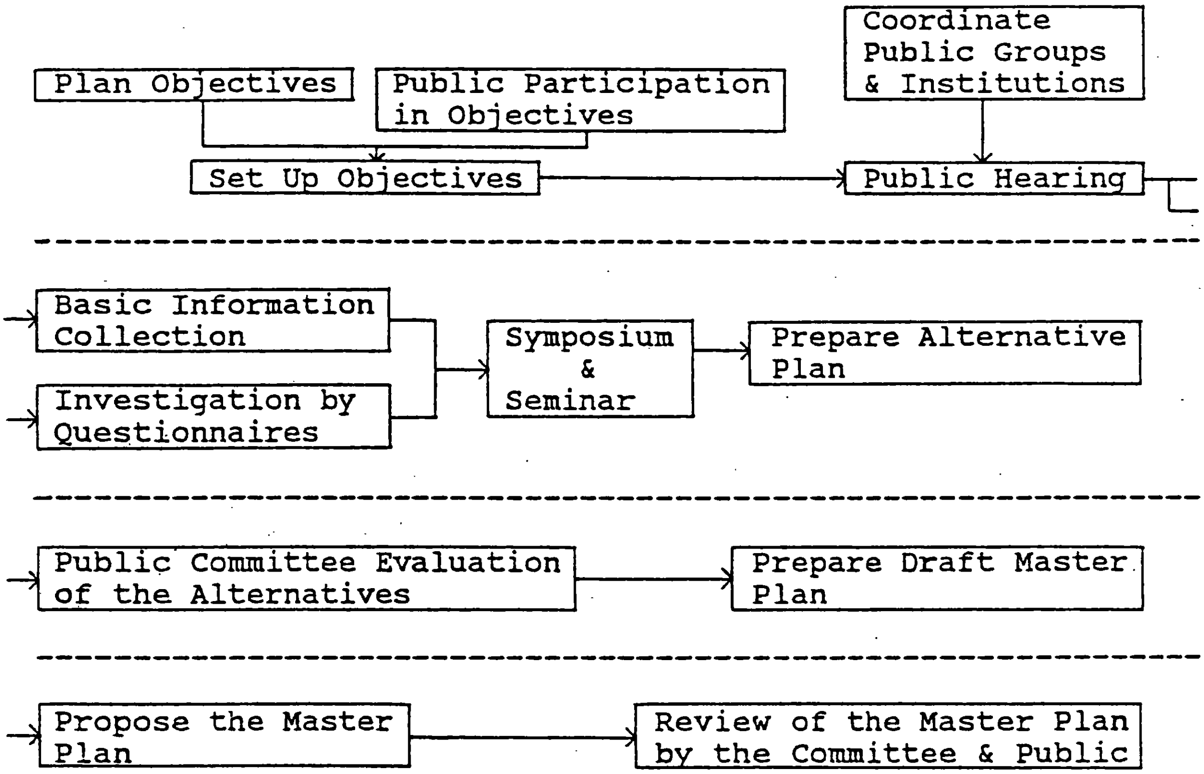


Figure 3.1 <u>Flow Chart of Planning with Public Participation</u>
(Source: Li, 1986)

In the process, it is better to have the public involved in each step of planning. However, there are several limitations to be considered: (1) the public's ability and knowledge of the subject and their conception of government credibility; (2) whether all government agencies involved are agreed on public participation; (3) the inefficiency, longer time frame and greater efforts required; (4) higher costs. To date, there have been only a few successful cases of national park planning in the U.S. and Canada which involve public participation. Golden Gate National Recreation Area and Yosemite National Park both in the U.S. are notable examples.[5]

Natural recreation resource planning is complicated and costs tremendous amounts of money, labour and time when it includes public participation. There is no doubt that public participation in planning not only raises the level of public education concerning recreation resource management, but it also collects sufficient information about public opinions and demands. Consequently, the plans meet the public's demands. In the long run, it saves on expenditures or unwanted facilities for visitors to recreation areas. Therefore, methods of involving the public are worthy of continuance.

3.2.2 Planning with the Recreation Opportunity Spectrum (ROS)

Recreation opportunity is created by a person in a special environment engaging in a recreation activity to obtain an expected recreation experience. In order to provide recreation opportunity, the following three conditions should first be understood: (1) the tourists' recreation experiences when engaging in the special recreation activity; (2) the special environmental conditions which are needed to meet tourists' recreation objectives; and (3) provision of the necessary environment to satisfy tourists desires for recreation experiences. Based on these ideas, Clark and Stankey proposed the ROS planning system, in 1979.[6]

The planning objectives of the Recreation Opportunity Spectrum are:

(1) identify recreation objectives;

(2) encourage planners and managers to recognise the importance of recreation activities, environmental qualities and recreation experiences;

(3) achieve a balance between recreation supply and demands;

(4) verifying recreation types, recreation volume and recreation quality and those that cannot or should not be provided;

(5) provide guidelines for management decision making;

(6) evaluate the effectiveness of recreation resource utilisation;

(7) provide information services to promote public participation in planning.

In order to achieve these objectives, a planning process can be followed:

(1) estimate the amount of demand according to the ROS classification;

(2) evaluate ROS quality and quantity;

(3) evaluate feasible types of activity and quality of ROS;

(4) develop alternative recreation opportunities;

(5) compile recreation opportunities and other resource uses;

(6) develop alternative resource allocation plans;

(7) set up a development plan;

(8) set up a management plan.

The ROS is still in the development stage, so there is no practical example available. But the following flow chart may be helpful in the implementation of ROS planning: (Fig. 3.2)[7]

In summary, the concepts of the ROS method are fresh and its theoretical bases are profound. It offers valuable principles that can be applied in planning. However, it does not give detailed definitions on recreation demand and supply. Neither does ROS give a standard for acceptable change to recreation managers. Furthermore, most recreation activities are provided because they are demanded by a majority of people. It is recommended that a study be conducted to determine the influence on individual

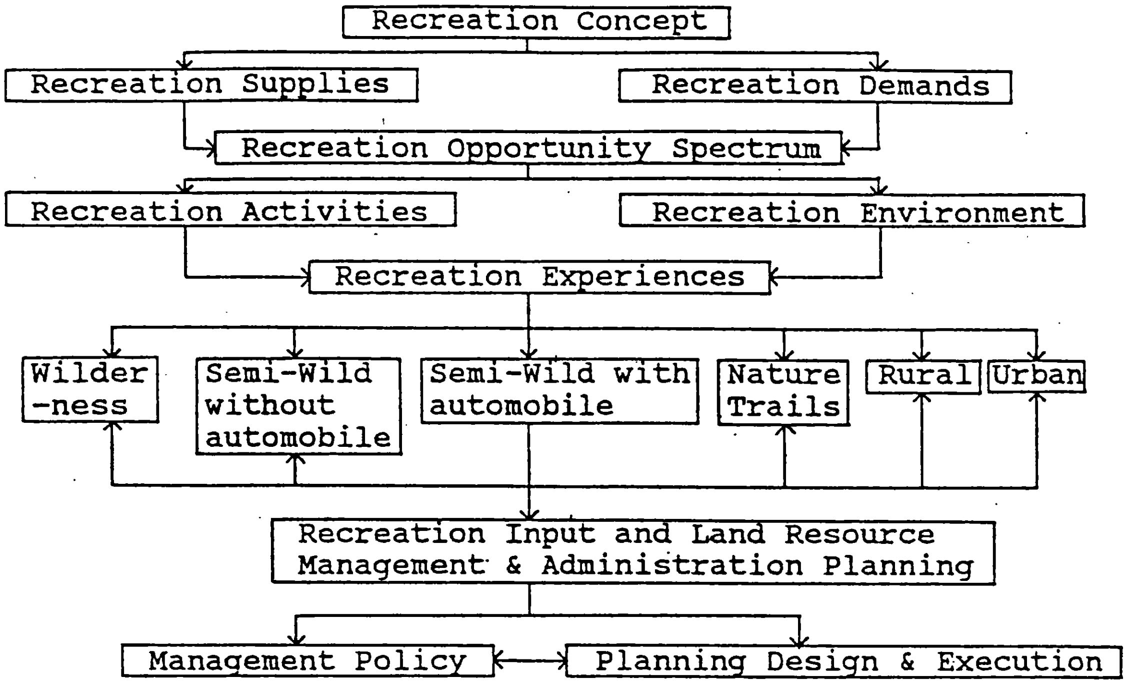


Figure 3.2 Recreation Opportunity Spectrum Flow Chart
(Source: Clark, 1979)

perceptions of the recreation experience due to crowded conditions. So that a rational management plan of the area can be set up to satisfy not only the majority of the users but also the recreation demands of more individalistic users.

3.2.3 Planning with the Limits of Acceptable Change (LAC)

The concept of ROS is adopted in this planning process. Three classes of recreation opportunity spectrum are delineated for the purpose of increasing the variety of recreation opportunities.[8] They are wild, semi-wild and simple. By using field survey, a criteria for the protection of environmental setting of wilderness areas can be made. Then, by the way of management measures, the ideal recreation environmental setting may be attained. Next, a monitoring system is set up to feed back information concerned and to periodically update management measures.[9]

This method requires definition of wilderness area status. Through management measures the desired recreation environment is achieved. The main steps of planning procedures are[10]:

(1) identify the problems of the recreation area and their significance;

(2) decide which problems should be solved;

(3) define and explain the scale of ROS;

(4) identify resource index;

(5) carry out resource surveys;

(6) draft standards applicable to various resource and social conditions;

(7) formulate ROS alternatives and management measures;

(8) evaluate all alternatives and select the best one;

(9) execute the plan, monitor resource and social conditions.

Although this method is still developing and no actual case exists, the process for the management of a recreation area has been carried out as shown below. (Fig. 3.3)[8]

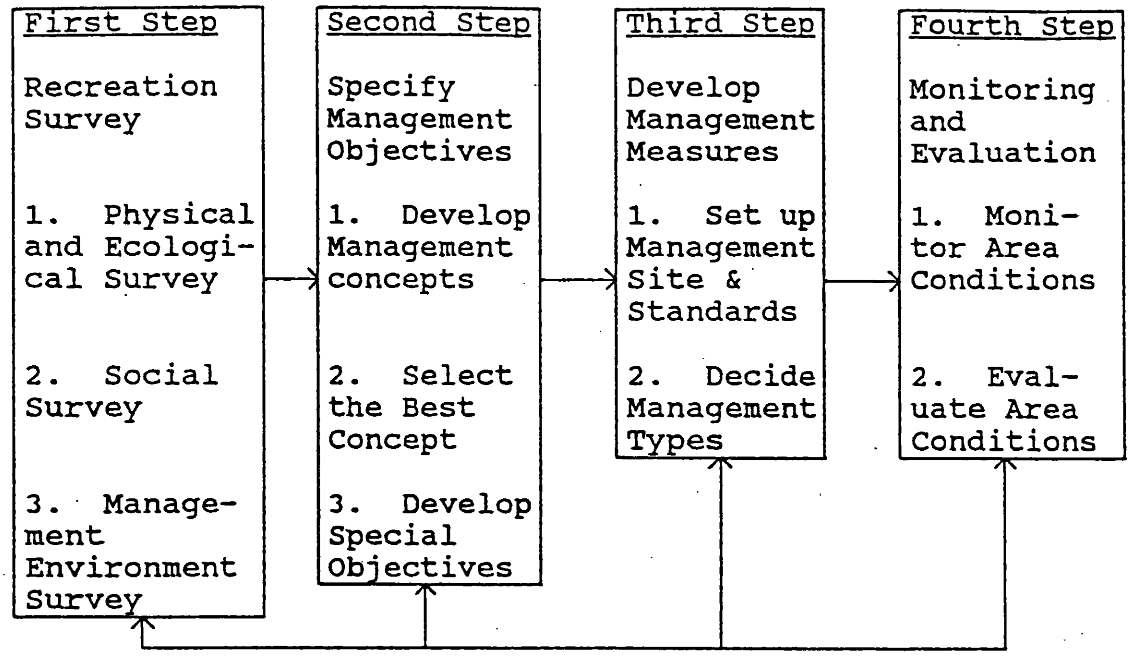


Figure 3.3 Recreation Planning Process of the Limits of Acceptable Change (Source: Stankey, 1984)

There is a close relationship between the LAC and ROS methods, but their planning concepts are quite different. The ROS method is based solely on the tourist experience and aims to increase the tourist recreation opportunity, but neglects the viewpoint of management. The LAC method supplements this shortcoming and offers a new planning concept. Yet, the concept is not perfect. Further research is needed.

3.2.4 Social-Psychological Carrying Capacity

The concept of recreation carrying capacity was first proposed by Lapage, in 1963. He considered that recreation carrying capacity was the maximal usage of a site when a satisfactory recreation experience is obtained by the majority of tourists without undergoing deterioration to the site. In 1964, Wager stated that a recreation site offers a certain psychological experience. Its acceptable usages are variable depending on the expectations of experience quality, management patterns, site factors, recreation types and visitors' characteristics.[11]

Application of the concept of social-psychological carrying capacity to recreation planning has been appearing in the literature since 1972. Among these is the concept based on economic utility theory proposed by Fisher and Krutilla (1972).[12] Their hypothesis is that tourists are a homogeneous group having a similar economic background. Tourists pursue a wilderness experience that may be termed "solitude" and can be indexed by the number of persons met on the way. This index is negatively correlated to tourist satisfac-tion. An increase in the number of tourists entering a recreation area decreases the tourist's degree of satisfaction. Degree of satisfaction may not fall to zero, but at a certain crowding index the recreation carrying capacity is reached.

In 1972, Tivy proposed that the law of the minimum or limiting factor should be applied in the determination of recreation carrying capacity. Also, a matrix analysis using a "land deterioration" standard as criterion is adopted.[13] On the other hand, Hammon (1974) used a system operation method to determine recreation carrying capacity.[14] In his system, the output data derived from system objectives should be so quantified that a comparison with a defined standard could be made.

In 1975, the Bureau of Outdoor Recreation, U.S.A. entrusted the Urban Research and Development Corporation to study the best system for determining recreation carrying capacity.[15] A total of seven Bureaus of Outdoor Recreation participated and offered their recreation areas for the study. A random sampling method was used. The survey results were compiled and those social and physical factors affecting the recreation carrying capacity were screened out. Based on the information the carrying capacity was calculated for each recreation activity. The drawback of the method is the subjective resource survey and the high cost of the survey.

Planning processes differ by area and by planning objectives. Nevertheless, the principle is to arrive at the optimal land-use plan by analysing and assessing the relationship between characteristics of recreation resources and visitor demands. In recreation planning, quality indices are determined first, then planners can figure out the recreation carrying capacity.

Recreation quality increases or decreases depending on whether the carrying capacity is not reached or exceeded, respectively. To apply this method, therefore, it becomes necessary to define a clear desired recreational quality as well as planning and management objective.

To date, the main purpose of using recreation carrying capacity in planning has been to use the results of calculations as an index for developing recreation resources. The process flowchart applying this method follows:[16]

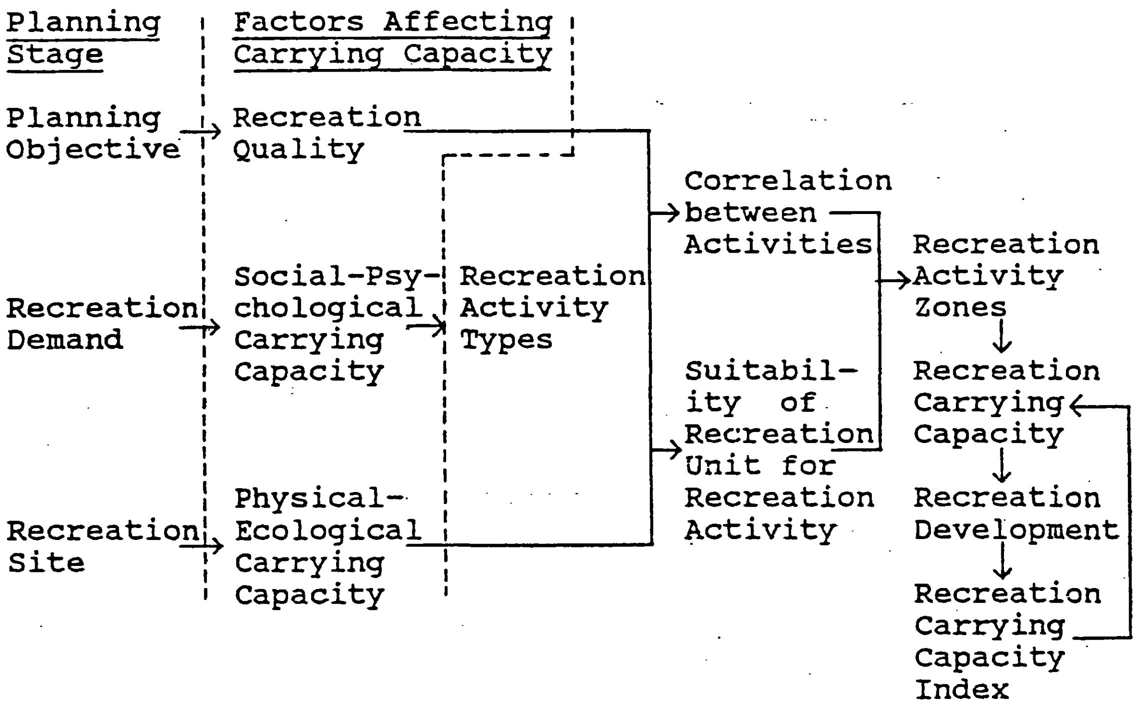


Figure 3.4 Recreation Carrying Capacity Measurement Process (Source: Stankey,1976)

It is evident from the "recreation activity zones" and "recreation carrying capacity" in the above chart that in the process, the recreation carrying capacity of each zone is measured based on the predesingnated land area. However, in the actual process the land allocation should be the end product. In other words, the measurement of land area should come after the measurement of carrying capacity which is merely one of the factors considered in the land use planning.

These methods are based on the theory of social-psychological carrying capacity. Among them, the BOR is the most practical and commonly used. In addition, the author carried out research entitled "A Study on Ta-Keng Tourism Farm planning".[17] The study showed that the application of the recreation carrying capacity concept to landuse planning is possible. A single objective linear programming model was used to find out the optimum landuse plan. Several alternatives can be carried out in a limited time. It was evident that the application of a mathematical programming model to recreation resource management is feasible. Furthermore, recreation carrying capacity has been used as an index of environmental quality, but it had not been used for physical planning. The result of that study challenged this lack and showed that recreation carrying capacity should be one of the major planning factors.

3.2.5 <u>Delphi Method</u>

This is a method developed at the Rand Corporation in the U. S., in 1960, through the cooperative efforts of several researchers.[18] It operates similar to the public participation method, but the public involved in evaluation is limited to specialists only. Several interviews, anonymous questionnaires and information feedbacks are provided to the participants. Finally, through shuffling and reshuffling individual opinions, it is reduced to a collective decision to be used in the planning.

The Delphi method was applied primarily on establishing objectives and predictions of future technological breakthroughs. In reality, it is the prediction of random events by consolidating group opinion. It does not involve itself with the participants' psychological hindrances. The actual application steps are shown in the flow chart below. (Fig. 3.5)[18]

The merit of the Delphi Method lies in the anonymous questionnaire survey which excludes undue pressures usually exist in a group meeting. Its merit also lies in the repeated operations which continuously feedback new information to aid in reaching a final decision. Therefore, the precision and level of confidence are quite high. However, the process is very complicated, the unit cost is high and the time needed to complete the process is long. Hardest of all is finding experts to participate in the project who are knowledgeable and can maintain objective views.

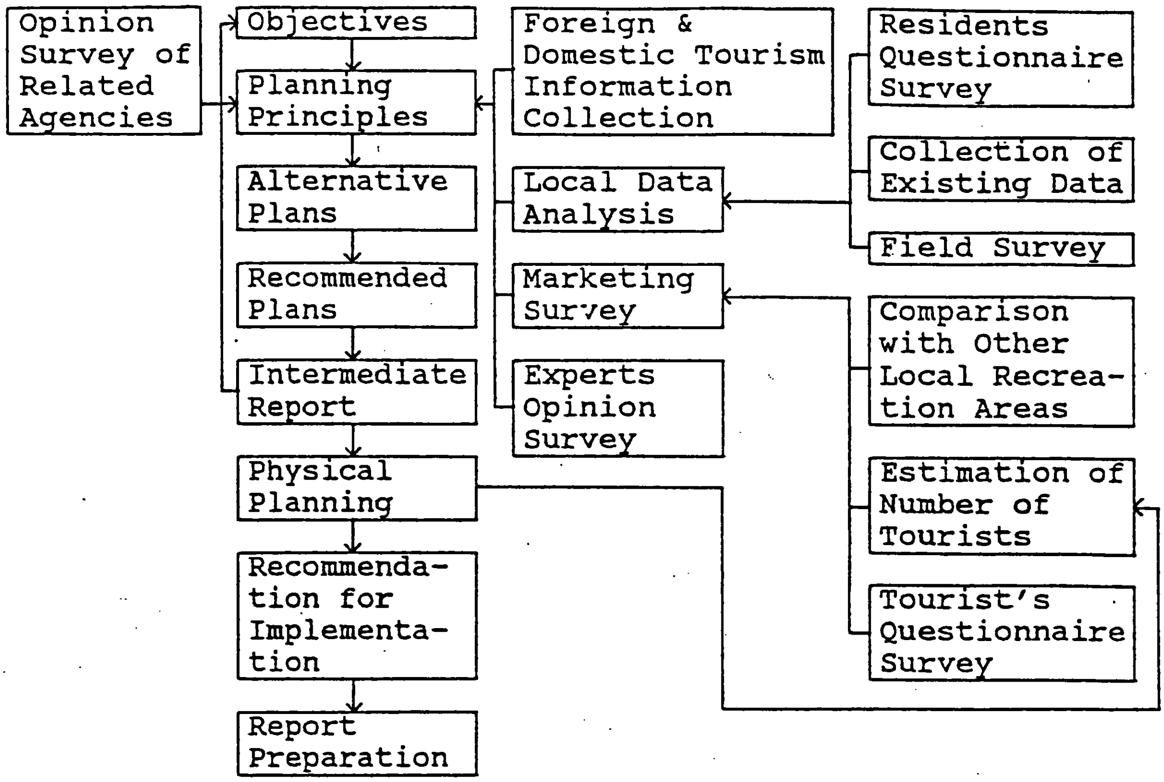


Figure 3.5 Flow Chart of Planning Using Delphi Method
(Source: Turoff, 1980)

3.3 Planning Methods Based on Ecology

A poor society may tolerate poor environmental conditions which, perhaps, are considered intolerable and disastrous to a developed, wealthy society. As an economy develops and GNP advances to a certain point, the ecological environment related to people's daily life becomes the focus of public attention. Again, from the viewpoint of recreational needs, it is obvious that modern humans living in a concrete jungle will not be entirely satisfied by artificial recreation facilities and simple physical stimulation. Therefore, in recent years, it has become fashionable to pursue and enjoy environmental conditions of an undeveloped natural status or wilderness area. In response to this trend, many new recreation areas have been opened. However, most of the recreation areas were developed without detailed investigations and planning. They have ended up causing undue depletion of limited resources and unnecessary destruction to the aesthetic natural environment.

Barry Commoner, who authored a book entitled The Closing Circle, has warned that we are on the way to commit suicide. The environmental debts accountable are clearly visible in front of our eyes. This suggests that we can take only one of two paths of action: (a) establish a rational society that can rationally utilise and allocate global resources, or otherwise, (b) resort to neobarbarism.(19)

A German environmental scientist, K. Buchwald, in his "Recommendation to the Republic of China's Environment Policy" pointed out that the primary target should be the perpetual maintenance of productivity of natural environmental resources. The second target should be to establish a consolidated land use model of the best combinations of aesthetics and ecology. The third target should be to establish and maintain the best multiple land use plan, in view of aesthetics and ecology.(20) Thus rational allocation, utilisation and conservation of nature resources have become an important theme of modern recreation planning and management.

According to data existing today, it is obvious that the destruction of natural ecological balance usually has been caused by improper land use. Only by careful planning can the faults be alleviated.

The followings are the important recreation resource planning methodologies developed from the viewpoint of ecology.

3.3.1 Ecological Planning Method

In the early stage, the ecological planning method tends to concentrate on the analysis of a single natural factor and the formulation of space structure. Scholars such as Angus Hills, Philip H. Lewis and Ian McHarg are the representatives of this method. Among these, Ian McHarg and his colleagues conducted a series of cooperative studies and experiments and formulated the ecological planning method. People involved in this work included Nicholas Muhlenberg, who introduced integrated ecological theory in 1966; an anthropologist, Dr. Yehudi Cohen, introduced anthropological theory; and Nacendra Juneia, who with McHarg, co-authored the natural resource survey of the ecological planning method.(21)

This method puts emphasis on the analysis of natural processes, for which the data collection and analysis of the resources are based on the degree and priority of the effect of natural factors. In the meantime, the relationship between land use and natural environment is analysed according to the opportunities and constraints of land so that optimal development allocation and patterning can be obtained.

The planning process of the ecological planning method is as follows:[22] (Fig. 3.6)

(1) inventory: define every single part of the system;

(2) analysis: analyse every single part of the system;

(3) synthesis: interaction between different parts of the system;

(4) alternatives: different development expectations from different users;

(5) implementation: strategies, methods, and processes for alternatives;

(6) testing: test after a long period the plan used.

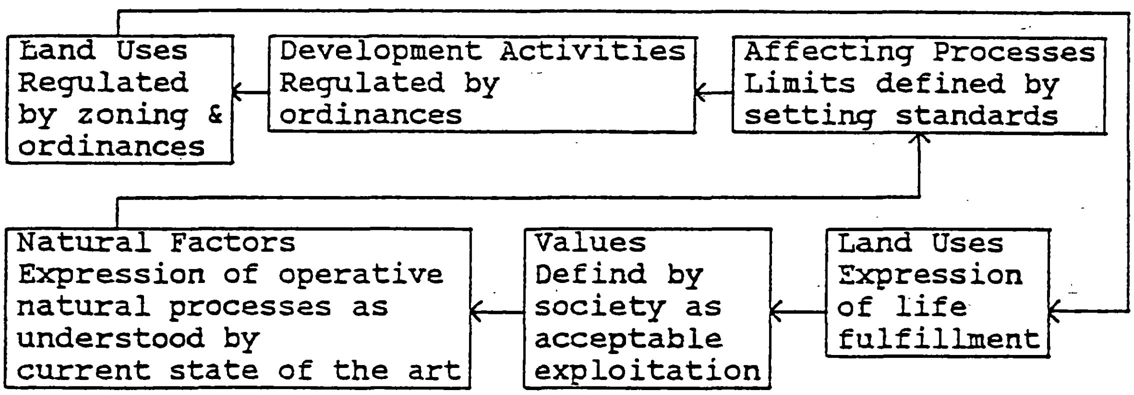


Figure 3.6 Guidelines for Ecological Planning (Source: Berger,1987)

Basically a scientific model is used to allocate land use in the method, i.e., the natural resources and social factors data are put into a model. Then the land-use types are analysed by a mapping technique. In the process, the method establishes a series of matrices to measure the criteria of each stage. Thus it has a feedback approach. In addition, the interactive relationship between different ecosystems is considered; also the interaction between human activities and the environment are predicted. However, subjective prediction in this method is not avoided and the mapping techniques are complicated and difficult to employ. This decreases the reliability of the results.

3.3.2 Physical-Ecological Carrying Capacity

Physical-Ecological carrying capacity was proposed by Neriker and many other biologists and ecologists in 1976.[(23)] The purpose was to assess the impact of visitors on the site, then decide whether the site should be closed for regeneration or opened for recreation. Thus a total of ten land ecosystems in Florida were selected to study the effects of hiking and camping activities on the site quality.

The data collected include soil density, root system, water precipitation, leaf litter weight, humus depth, grass and seedlings, shrubs, climbers and so forth. The data collected were then compared with the control area data; the effects of hiking and camping on the environment was measured. Finally, a matrix graph was used in displaying tolerance limits of the ecosystems.

From the measurement of physical-ecological carrying capacity (Fig. 3.4), it is evident that the tolerance limit in this method was used as the planning base in deciding which kind of recreation activities, what intensity of development and which management objectives should be taken to prevent the area from being over used ecologically. Whenever the intensity of recreation exceeds the tolerance limit the activities should be curtailed.

However, an energy flowchart based on the energy flows occurring in the ecosystem was constructed in this method. Within the flowchart, several of the measurable points were selected for observation. Therefore, the method puts emphasis on ecological aspects of the ecosystem and neglects other related factors; in addition no systematic study and analysis were made for recreation activity demands.

3.3.3 Regional Ecological Planning Method

The Director of the Graduate School of Landscape Architecture and Regional Planning, the University of Pennsylvania, Ian McHarg, proposed an ecological planning method in 1975.

The method is based on the hypothesis that the natural environment is a product of evolutional processes that are mutually controlled and affected between geological and ecological factors. The relationships or interactions between the factors are shown below.(24) (Fig. 3.7)

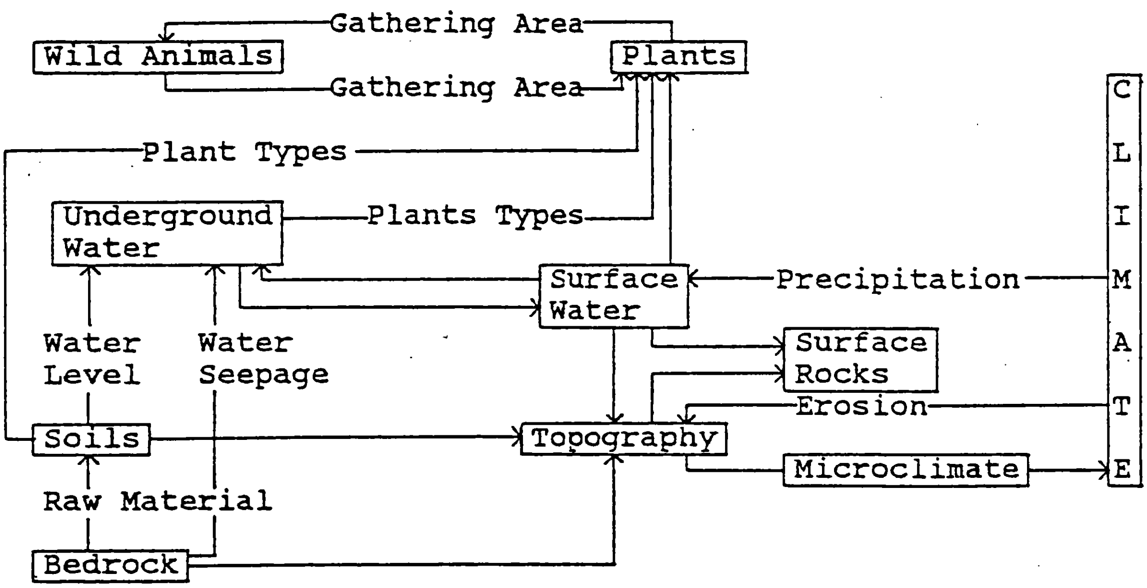


Figure 3.7 <u>A Simplified Movements of Natural Environment Elements</u>(Source: Chen, 1981)

The method requires thorough observation of the interactions between various natural environment factors to really understand the ecosystem of a given area. Steps required in the ecological planning method are:

(1) define an ecological planning area based on land or area ecosystem unit, not on administrative unit;

(2) evaluate the environmental resources, prepare an information base map and incorporate ecological and

sociological data on the base map;

(3) analyse the supply-demand situation on the base map, and assess the recreation supply capacity including fragile and dangerous areas and the level of social demands including demands for industrial construction;

(4) prepare land use plan, construct land use suitability survey maps, and then check with land information records and define proper planning frame;

(5) evaluate the effect of new plan on ecosystem. It is divided into three categories:

a. effect of change during site preparation period;

b. permanent effect caused by construction of permanent structures;

c. effect on workers' daily life during construction period.

(6) evaluate each resource separately in terms of its environmental factors relative to various land use opportunities and limitations;

(7) make an overall evaluation of land use suitability;

(8) evaluate the compatibility of land use between the area and adjacent outer areas, retaining those compatible uses and separate those contradictory ones;

(9) evaluate the compatibility of land use within the plan area, use the map overlay method to find the best land use combinations and identify those land uses which are acceptable on the same site;

(10) carry out a small-scale preliminary assessment, select special and small-scale sites and execute a resource assessment;

(11) conduct an Environmental Impact Assessment, evaluate the impact of human behaviour on the environment which could have negative or positive influence, feed back the assessment and modify the land use plan.[25]

The processes above are summarised in the following chart.[26]

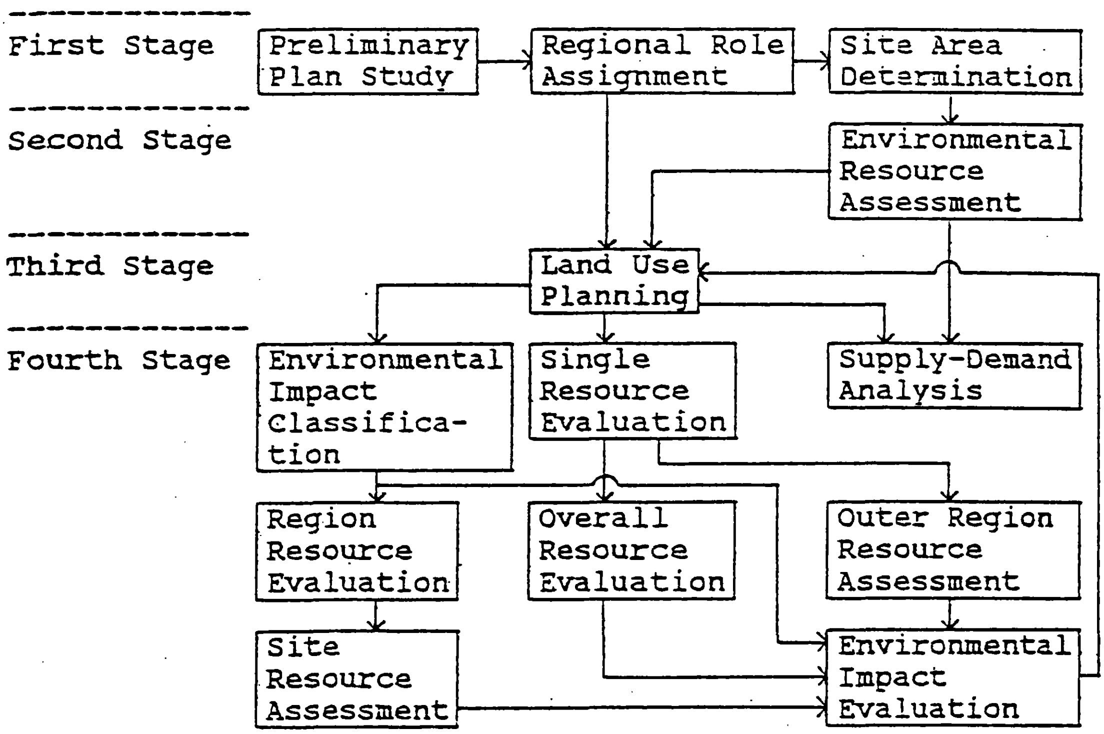


Figure 3.8 <u>Flow Chart of Simplified Ecological Planning Process</u> (Source: Hwang, 1982)

The simplified ecological planning method is a well organised system, has a clear flow of production processes and calls for a wide and thorough resource investigation. Therefore, it has provided illustrative explanations and indices for evaluation of future human behaviour on the environmental factors which are fed back to modify the land use plan.

As to land allocation, it is based on the land use classification indices and environmental factors. A matrix is then made by using land use opportunity and limiting indices. Land use classification is determined by the mapping method. The environmental factors are evaluated by three levels, high, medium and low to provide an index for land use form selection. This method has provided detailed evaluation tables or matrices at each planning stage. However, the tables or matrices are not quantified.

3.3.4 Landscape Planning with Ecological Structure

This method was proposed, in 1978, by K. Buchwald, Director of Landscape and Nature Technology College, Hannover University, West Germany. The method stresses the importance of ecological environmental factors in landscape planning. Also, in a diagnostic environmental survey, special attention is paid to the determination of the stability of the ecological structure and the ecological and visual conflict zones caused by different land uses.[27] The planning procedure flow chart is shown in Figure 3.9.

This method of land use planning is based on the stability of the ecological suitability and the inter-relationship between ecological and visual evaluation of the landscape for different landuses. The method stresses the importance of landscape and ecological diagnosis, but neglects recreation activities and other influential factors. Moreover, from the landscape evaluation and ecology diagnosis, it is possible to wisely estimate the ecological and structural suitability for landuses and zones of ecological and visual conflicts caused by uncompatible landuses. However, no explanation is made about how to solve the problems. Also, no explanation is made about the study and analysis of people's demands for recreation activities.

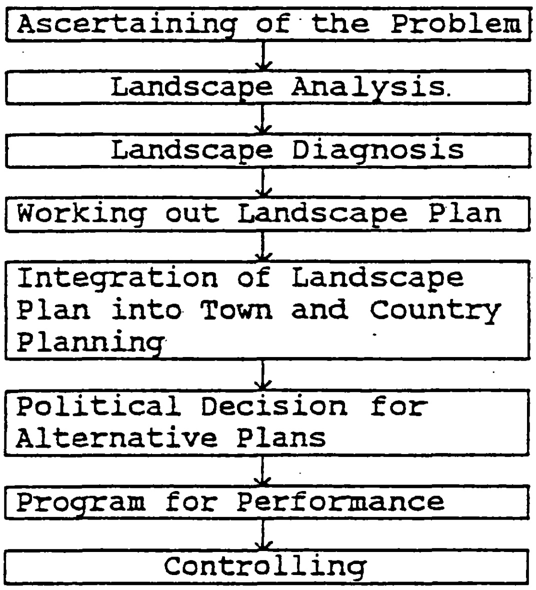


Figure 3.9 <u>Flow Chart of Landscape Planning with Ecological Structure</u> (Source: Buchwald, 1978)

3.3.5 <u>Landscape Ecology Planning Method</u>

This method was proposed by the present author, in 1985, in the research paper "A Study on Landscape Planning for the Third Nuclear Power Plant Site and Its Surrounding Area".(28) The method employed aerial photo maps overlaid with appropriate size of grid cells according to the site character, and divided the area into more than ten thousand grid cell units. Two computer programme packages, called MAP and VIEWIT were used to analyse the natural environmental factors of each cell unit. The input data include information about topography, slope, aspect, soil, geology, microclimate, zoological and biological ecology, environmental visual quality and others. Another computer programme package, BIBLE, was used in analysing and compiling the ecological status of each cell. All the data were filed in the data bank and can be updated. The data will be combined with related data, such as social and economic factors, recreational factors, acts and codes and data gathered from questionnaires, for the purpose of preparing alternative land use plans. The master land use plan then can be selected after evaluation. The other related detail plans were proposed. These included the ecological conservation and soil erosion control plan, landscape improvement plan, recreation plan, interpretation plan, transportation management and improvement plan, detailed plan, phasing and zoning plan, financial plan and management plan. The overall planning procedure is outlined below:(29)

1. establish planning theory and method;

(1) study related plans and regulations

(2) understand clients' demands

(3) provide information about the environment from a professional judgement

(4) establish planning objectives

(5) establish work list to attain the planning objectives.

2. carry out surveys and analyses;

(1) natural environment: topography, soil, geology, microclimate, water resources, animal and plant ecology, etc.

(2) social-economic environment: population, present land use, ownership, production activities, public facilities, transportation, existing buildings, future development plan, etc.

(3) visual analysis: road visual sensitivity analysis, landscape spacial quality analysis, scenic spots viewshed analysis, objective visual computer analysis, etc.

(4) tourism and recreation: natural and artificial recreation resources, tourist numbers and tourist activity models, existing and planned recreation facilities and activities, existing and planned interpretation system, limiting factors in developing recreation.

(5) pollution problems: air, water, noise, garbage, etc.

(6) questionnaires: residents, tourists, employees, etc.

3. synthesise and establish overall planning criteria;

4. complete master plan;

5. complete detailed plan;

6. complete planning work.

The process flow chart is shown in Figure 3.10.[29]

The Landscape Ecology Planning is based on an in-depth theory and clear planning process and evaluation methods. The investigation of environmental resources is widely examined in this method. The interactions between ecosystem factors is considered. As to the allocation of the land base to proper uses, the method takes into account all requirements and analyses, considers planning constraints, confirms with related agencies, builds land use allocation standards, and finally make alternative land use plans. These alternative land use plans adopt the weighted indexing formula for evaluation.

This method takes advantage of a computer to analyse complicated data and summarises it into the evaluation base with emphasis on ecology. It also take the ecology conservation concept and recreation function into industrial site landscaping and land use planning. Not only does it call for a systematic analysis of whether the

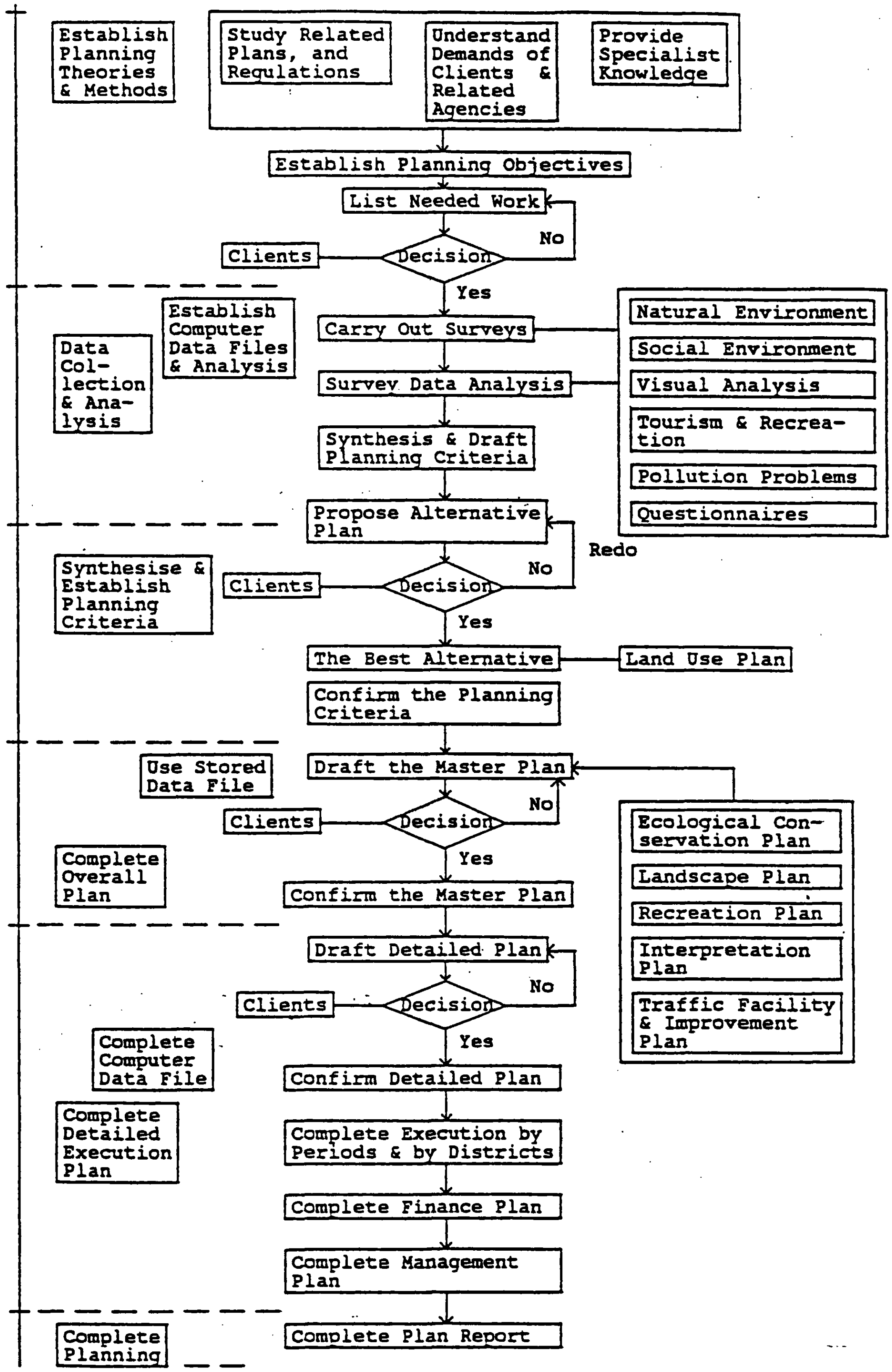


Figure 3.10 Flow Chart of Landscape Ecology Planning
(Source: Wang, 1986)

industrial use should be developed of the ecological environment conserved, but it also provides a rational land use plan. The method was applied subsequently in "A Study on Landscape Planning and Design for the First Nuclear Power Plant Site",[30] "A Study on Landscape Planning and Design for the Hsen-Aoh Electric Power Plant Site",[31] and "A Study of the Ta-Keng Hillside Housing Estate Development Models in Taichung".[32]

3.4 Evaluation of the Existing Methods

To further understand the differences and similarities and the advantages and disadvantages of each method, further evaluation is made of the planning methods based on sociological and ecological factors, respectively.

3.4.1 Planning Methods Based on Sociology

1. Evaluation Items :

(1) Unit cost;

(2) Length of operation time required;

(3) Complexity of the operation procedure;

(4) Whether it is easily affected by man-made factors, hence lowering its reliability;

(5) Whether it has particular difficulties;

(6) Whether it has particular value;

(7) Whether it could be quantified;

(8) Whether it is helpful for land use planning.

2. Evaluation Results :

(see Table 3.1)

3.4.2 Planning Methods Based on Ecology

1. Evaluation Items :

(1) Practicality of land use

The main points are

a. Whether there is a reliable process for planning land use;

b. Whether the land use is based on the results of resources survey and evaluation;

c. Whether there are alternative evaluations and post-feedback evaluations.

(2) Quantifiability of the method

The main points are

a. Whether quantification can be made during resources evaluation;

b. During the evaluation of land use, whether its suitability can be quantified so as to determine its area size;

c. Whether the post-land use evaluation can be quantified.

(3) Comprehensiveness of the method

The main points are

a. Whether the research includes all important factors;

Table 3.1 Comparison of Planning Methods Based on Sociology

Planning Methods	Results	Advantages	Disadvantages
A. Public Participation	Through sufficient data collection, presentation and discussion meetings, public opinion is ascertained.	1. Public opinion can be sufficiently collected and public demands understood. 2. Educational effect can be achieved. 3. Planners and managers can provide necessities according to public demands.	1. Unit cost is too high. 2. Operation is too complicated and time-consuming, and easily causes disputes.
B. Recreation Opportunity Spectrum (ROS)	Considers recreation demands, resource possibilities and capacity factors as the basis for land use to form a comprehensive plan.	1. Has solid theoretical basis. 2. Addresses planning principles and direction of future study.	1. Tends to be theoretical, not practical. 2. Only gives a hint of ideas and principles; not practical in land-use planning.
C. Limit of Acceptable Change (LAC)	Based on a series of measurable parameter to define each recreation experience and then to maintain or achieve the desired state.	1. Various recreation experiences can be defined.	1. Detailed resources and demands surveys must be conducted at high cost. 2. The idea is new, but not practical.

Table 3.1 Comparison of Planning Methods Based on Sociology (contd.)

D. Social-Psycho-logical Carrying Capacity	Fisher & Krutilla	Determines wild land recreation carrying capacity based on economic theory, that is, "satisfaction is willing to pay." Value is counted in cost-benefit.	1. Most of these methods are based on surveys and interviews. Therefore, what they represent is only a model of a particular time in a particular society. The results change as the social structure changes. 2. Data collected by different operators on the same site are often divergent. 3. The effects of recreation activities on the affecting factors of the carrying capacity are diverse, so the various weights added to factors often affects the outcome. 4. The methods proposed by Fisher and Krutilla, Hammon and BOR are all practical methods for measuring social carrying capacity. Among these BOR is the simplest and most practical , but criteria is difficult to set up.
	Tivy	Makes use of a matrix and takes "site deterioration" as the standard to find the optimum carrying capacity.	
	Hammon	Uses systematic operation to calculate the unit (person, car, boat) amount that momentarily occupies any area within the system.	
	Jaakson	Uses diagram to evaluate land and environment data and map overlay method to find the carrying capacity of each area.	
	BOR	The best range of	

Table 3.1 Comparison of Planning Methods Based on Sociology (contd.)

	(URDC)	carrying capacity can be obtained through the analysis of the present situation areas. This range can be used as a basis for planning, design and management of the areas.		
E. Delphi Method		Uses questionnaire lists to obtain stringent answer by making repeated feedback to professionals.	1. Facilitates close group communication and decision making. 2. Diminishes group pressure by facilitating anony mous decision making. 3. Reliability and accuracy are higher by eliminating personal views to obtain a rational conclusion.	1. The operation process is complex. 2. High unit cost. 3. A time-consuming operation. 4. The professionals must possess a proper level of knowledge. Thus their selection is rather difficult.

b. Whether it is made concurrently for some particular or easily overlooked effects and expected effects.

(4) Exclusivity of the method

The main point is whether there are environmental factors to be repeatedly considered.

(5) Selectivity of the method

The main points are

a. Whether unimportant factors can be eliminated and consideration of the main factors emphasised to save time, money and speed decision making;

b. Whether plan alternatives are considered and whether the choice is flexible and rational.

(6) Objectivity of the method

The main points are

a. Whether the methods and procedure are scientific;

b. Whether the theoretical basis is extensive;

c. Whether the evaluation is quantifiable and objective.

(7) Dynamics of the method

The main point is whether the planning process includes interaction and feedback.

(8) Accuracy of the method

The main point is whether scientific methods and instruments are used.

(9) Predictability of the confidence limits of the method.

The main points are

a. Whether there are many uncertainties that must be presumed subjectively. If there are, the confidence drops;

b. Whether there are clear evaluation procedures;

c. Whether the surveys of the resources and environment are extensive enough.

(10) Suitability of the method

The main point is whether the environment and scale are suitable for the method.

2. Evaluation Results :

(See Table 3.2)

3.5 Conclusion

Since recreation resource planning is an important but complicated task, it should have strong theoretical foundations and employ scientific methods. Heretofore, various experts and scholars of different backgrounds and points of view have proposed planning theories and methods of different scope and dimensions. None of the theories and methods, however, seems entirely rational, complete and unbiased. For instance, the planning methods based on sociology try to meet human recreation demands as a major objective, yet ignore the limited carrying capacity of the recreation resources. Their discussions are concentrated on developing and establishing concepts and neglecting the

Table 3.2 Comparison of Planning Methods Based on Ecology

Methods / Items	A. Ecological Planning Method	B. Planning Methods Based on Ecological Carrying Capacity	C. Regional Ecology Planning Method	D. Landscape Planning with Structure Method	E. Lanscape Ecology Planning Method
Land Use	1. Uses a detailed land-use planning process by diagramme, analysis and map overlays. The alternative plans come from each requirement based on the resources evaluation and demand analysis. 2. In the flowchart, sets up a series of matrices to check the operation stand-	1. Based mainly on observation and recorded results of the vegetation and soil, surveys and their relationship with recreation activities, converts them into matrix data of the ecological system that are tolerant of the recreation activities. Thereby proceeds with land-use planning. 2. There is no obvious operation procedure , so it is difficult to know how to	1. Check land-use classification selection index with the environmental factors to formulate the the opportunity and constraint matcries. Then use mapping to determine land-use plan. 2. In each phase of the method, detailed evaluation is made from the lists and matrices.	1. Land-use plan proceeds according to the adaptability of the environmental ecological structure. But a physical land-use planning method has not been brought out. 2. Uses the relationship of the ecological element and the data as basis to make	1. Based on detailed survey and analysis. Use a computer programme to analyse and overlap every natural environmental factor. Finds out different classes of the ecological situation on the site. Then land use is planned according to the planning criteria and the strategy is brought out. 2. For alternative land-use plans, index-weighted scoring is adopted for evaluation to

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

	ards. It is a circular evaluation.	conduct the land-use planning.	The evaluation results are applied to the land-use plan. Subsequently the environment is evaluated.	land-use plan.	determine the best one.
Quantification	1. A series of matrices are set up in every phase for the purpose of checking. Therefore, evaluation has been quantifiable. 2. In the land-use plan, map overlays are adopted. Planning size is based on demand analysis. Thus land-use planning is also quantifiable. Nevertheless, the mapping	In the soil and vegetation observation records including speed of water penetration, soil density, root system, etc., all are recorded as numbers and turned into "Changeable percentages" used as indexes.. Then, with X=10/the highest changes as the equation to calcalate the effect-data, they are placed into matrices. With this method	1. In land-use planning, some of the indices are quantifiable. Those that are not can still be used as the basis for determining the priority of land-use. 2. This proceeds through format, matrices and diagrams for evaluation. Not all are quantifiable.	Because the ecological element can be set apart and further analysed, they can be quantified. But there is no information to show how the quantified data are used afterwards.	1. The results of the resources survey and evaluation are quantifiable. 2. The suitability land use is indicated by indices. However, land-use planning is indicated by diagramme. They are not clearly quantifiable.

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

	operation is rather difficult.	soil and vegetation be quantified.			
Comprehensiveness	1. Physical-ecological and social-phychological factors are taken into consideration and formed into matrix in this method. Survey of the aspects ranges thoroughly and extensively. 2. Based on the above analysis to determine land use, it is a detailed, practical, and reliable process. Thus it has comprehensiveness.	1. Based on the energy flow transformation of the vegetation, a diagram is made from which some measurable changes are found. Next, ecological system observations and recordings proceed. 2. Because the main theme is plant ecology, it has no comprehensiveness.	1. The environment survey and demand consideration factors of this method are thoroughly and extensively. 2. To determine the land-use plan, index matrices are adopted. Factors listed in the matrices include geology, soil, topography, present use, etc. All have comprehensiveness.	Analysis of environmental factors are emphasised, especially suitability of the ecological structure of land use. It is a method restricted to ecological diagnosis. Thus it has no comprehensiveness.	1. The resources survey ranges thoroughly and extensively. 2. Based on resources survey evaluation and present conditions, the land-use plan is formulated. Thus is has comprehensiveness.

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

Exclusivity	The relationship between constraint and opportunity maps exclusivity.	Its land-use plan is based completely on the matrix data of the ecological system tolerance of the recreation activities. It is restrained when the tolerance is exceeded. However, no sign of the conflicts and restraints between ecological conditions and recreation activities are shown.	Classifies land-use criteria as "completele unsuitable region", "Strictly restrained region", etc. When the situation of the resources factors in conflict with the demand requirements is met, restraint is applied and the land is used in a different degree.	From its landscape and ecological diagnosis, the adaptability of the ecological structure and the ecological visual conflict zone produced after land use can be understood.	For the factors that conflict, the weighted scoring method is adopted to handle unavoidable exclusivity.
Selectivity	1. Its land-use plan is determined by finding the relationship between land-use demands and natural factors before the requirements are	1. Neglecting consideration of other factors, it focuses on important points of the plant ecology. It has absolute selectivity in the relation-	1. Each of the oppprtunity and constraint indexes of the land-use types is classified into high, middle and low. Then the land-use types are	1. In the process of planning, the important points of landscape ecology have been addressed, while activities and other factors have been neg-	1. Environmental factors are weighted by scoring. Important factors have highly weighted scoring; otherwise with lightened scoring. It has

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

	listed. Certain factors are naturally weighted while unimportant factors are neglected. Thus it has selectivity. 2. Alternative are not considered.	ship between plant ecology and recreation activities. 2. Alternatives are not considered.	selected based on the indices. 2. Evaluation of the alternatives is considered.	lected. Thus it has absolute selectivity in relation to the envirnmental-landscape ecology. 2. The plan has selectivity.	more selectivity in land-use planning. 2. Has an alternative plan to provide the best choice.
Objectivity	1. Has a deep theoretical base, either in ecology or sociology. All are discussed in detail. 2. The results are completely evaluated by the planners.	1. The procedure of the method are systematic and can be quantified. 2. The theory is reliable but not extensive enough. 3. The results are completely evaluated by the planners.	1. Has a complete system and clear procedure. 2. Has a firm theoretical base and systemised evaluation matrices. However, it has not been quantifiable. 3. The results are completely evaluated by the planners.	1. The flowchart of this method is systematic and can be quantified. 2. The contents surveyed are thorough, but not extensive enough. 3. The theoretical base has not been clearly explained.	1. Has a systematic method and clear flowchart. 2. The theoretical basis are thorough. 3. Has a quantified indices evaluation table.

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

				4. The results are completely evaluated by the planners.	4. The results are made from participants of various fields. Thus the plan has objectivity.
Dynamics	This method has a close connection with the interaction between factors. Unfortunately it has no feedback process.	1. Consideration of the plant ecosystem is comprehensive. But in the ecosystem, vegetation is not the only factor needing consideration. Therefore, the nature of the interaction is not sufficient. 2. No feedback process.	1. Has a comprehensive survey of the interaction of ecosystems. 2. Its environmental impact evaluation can predict the impact of human behaviour on the environment. Used to adjust the land-use plan.	1. Has overall consideration of the ecological landscape, but toward environmental diagnosis. 2. It has a feedback process.	1. Takes an overall survey of interaction within the ecosystem. 2. It has feedback evaluation.

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

Accuracy	Computer techniques are not used.	Ditto	Ditto	Ditto	Computer techniques are used.
Reliability	1. Resources and environmental surveys range extensively and are made into matrices. 2. There are clear planning and evaluation procedures. 3. Objective prescription can not be avoided. But the survey operation and information collection can lessen the subjective descriptions.	1. Has a distinct research flowchart. But how the last tolerance matrices are practically applied to land use has not been clearly described. 2. Although the survey ranges thoroughly enough, extensity is not sufficient. Reliability is affected.	1. Has a clear operation flowchart and evaluation method. 2. It is thorough and extensive in the environmental resource survey, hence subjective descriptions can be lessened.	1. Has a clear planning procedure. 2. Survey ranges thoroughly but not extensively.	1. Has a distinct operation flowchart and evaluation method. 2. It is thorough and scientific in the survey and analysis of the environmental resources. 3. It has more convincing vigour.

Table 3.2 Comparison of Planning Methods Based on Ecology (contd.)

	Therefore, the reliability is very high.				
Suitability	More Suitable for the natural environment and a large site.	Suitable for the environment which ecological factors are the main issues.	More suitable for the natural environment and a large site.	More suitable for a large site.	More suitable for the natural environment and a large site.

implementation phase of plans. Particularly, they have not proposed an effective land use plan. Nevertheless, some of those methods have contributed to the advancement of resource planning techniques and are worthy of mention.

1. Notable methods are Recreation Opportunity Spectrum (ROS) which emphasises quality of recreation experiences, and Limits of Acceptable Change (LAC) which emphasises effective utilisation of resources. The ROS offers many kinds of recreation opportunities to obtain the best quality of recreation experience. Although it considers carrying capacity of the resource limits, no clear guidelines for acceptable change are given. It creates not only confusion and difficulties, but also creates chances of disastrous mismanagement of recreation resources. LAC provides for multiple use of recreation resource and considers the protection of natural resources. It also tries to supplement the shortcomings of the ROS method by monitoring management activities, then feeds it back at the time of updating the plan. However, there is no actual case in which to observe the feasibility of the plan.

2. The Public Participation and Delphi Methods have been widely adopted. The former has as its starting point the participants' views and interests. Thus the quality of the resulting plan is greatly influenced by the quality of the participants. However, there are almost no controls on resource utilisation and planning. As for

the Delphi Method, it has implemented expert diagnosis and helped slightly in forming sound policies. However, unless they have critical views on the recreation resource of the area, they end up suggesting only general principles for the planning. Therefore, the selection of experts is the key to the method.

3. In the application of social-psychological carrying capacity in recreation planning, Fisher and Krutilla, and Hammon placed more stress on the demands of tourists and less on physical-ecological carrying capacity. The URDC took into account both social and ecological carrying capacities, but did not explain clearly how to use them in planning nor in management.

In general, planning methods based on sociology have an indepth theoretical base, they are slightly biased towards tourist demands and are not practical for implementation in actual planning.

As for the planning methods based on ecology, they also have advantages and drawbacks.

1. The ecological planning method applies natural science as basic knowledge and uses mapping techniques to allocate different uses of land. It is a comprehensive planning method and can be used to plan large-scale sites, such as countryside and new towns where ecological factors are the most critical factors to be considered.

However, the complexity and difficulty of the mapping technique and the subjective judgement of operators decrease the accuracy of the results.

2. The physical-ecological carrying capacity method, proposed by Nerikar and others, is based on data obtained through intensive ecological surveys and the level of tolerance of recreation activities calculated for each ecosystem in the recreation planning. The method is suitable for planning areas with natural topography and/or wildlife resources, but it is not suitable for recreation areas with historical remains and relics or artificial construction with cultural value. Further study is needed on the application of this method in the physical planning process.

3. Regional Ecological Planning theory and method, proposed by Ian McHarg and his colleagues, employs a series of mapping analysis and thereby derives basic data for land use classifications. At each analysis different matrices are used for examination and verification. At the same time, an environmental impact assessment is carried out for those areas already in use. Thus the method is well designed and factors are very thoroughly considered and examined. The only criticism is that the land use classification is based on the overlaying of various suitability maps, so that the precision of area measurement for each land use unit is debatable. Also,

tourist demands and the limitation of acts and codes are not taken into consideration in the planning.

4. The Landscape Planning with Ecological Structure Method, proposed by Buchwald, over-emphasises ecological diagnosis and neglects the quantitative aspects of areas in use.

5. The Landscape Ecology Planning Method, proposed by the present author, takes into consideration various social and ecological factors. It incorporates demands of users and clients and employs professional knowledge, so that the feasibility of the method is greatly increased. While most of the evaluation of factors is quantified to increase statistical reliability the precision of land use area was left for future improvement by rational and advanced scientific methods. Economic factors, also, are taken into consideration during planning to make the method more complete.

REFERENCES

1. Perry, J. Brown : "Planning for the Use of Recreation Resources". International Symposium on Landscape and Recreational Planning, Taipei, ROC, 1985, p. 7.

2. Driver, B. L. and S. R. Tocher : "Toward A Behavioural Interpretation of Recreational Engagement, with Implications for Planning". In Elements of Outdoor Recreation Planning, B.L.Driver (ed.), Univ. of Michigan, Ann Arbor, Michiqan, 1970, p. 21.

3. Ibid. 1, pp. 8-9.

4. Li, Min Tsung : "Brief Introduction - Public Participation in National Park Planning Process in the U.S. and Canada". (in Chinese), Taiwan Forestry, Vol. 12, No. 5, ROC, 1986, pp. 12-13.

5. Lanton, Stuart (ed.) : "Citizen Participation in America", 1978. p. 32.

6. Clark, Roger N., and George H. Stankey : "The Recreation Opportunity Spectrum : A Framework for Planning, Management and Research". USDA Gen. Tech. Rep. PNW-98, U.S.A., December 1979, pp. 21-30.

7. Ibid. 6. pp. 18-24.

8. Stankey, George H., et al., : "The Limits of Acceptable Change : A New Framework for Managing the BOB Marshall Wilderness Complex". Western Wildlands, Vol. 11, No.3, Univ. of Montana, Missoula, MT, 1984, pp. 33-37.

9. Stankey, George H., et al., : "The Limits of Acceptable Change for Wilderness Planning". USDA Forest Service Gen. Tech. Report, INT-176, USDA, Intermountane For. and Range Exp. Sta. Ogden, Ut. U.S.A., 1974, p. 8.

10. Chen, Shui Yuan : "A Study on the Relationship between Recreation Experience and Environmental Factors". (in Chinese), A Report to National Symposium on Recreational planning, National Taiwan Univ., Taipei, ROC, 1987, p. 2-23 -- 3-3.

11. Wager, T.A. : "The Carrying Capacity of wildlands for Recreation". For. Sci. Monogr. 7. 1964. pp. 23-39.

12. Fisher, Anthony C. and J. V. Krutilla : "Determination of Optimal Capacity of Resource-based Recreation Facilities". Natural Resource Journal, No. 12, School of Law, Univ. of New Mexico, N.M., U.S.A., 1972, pp.417-444.

13. Tivy, Joy : "The Concept and Determination of Carrying Capacity of Recreational Land in the U.S.A." Countryside Commission for Scotland, CCS Occasional Paper No. 3, U.K., 1972, pp. 1-21.

14. Hammon, G. A., et al., : "Capacity of Water-based Recreation System Part I: The State of Art -- a literature review". Water Resources Research, Institute of the Univ. of North Carolina, U.S.A., 1974, p. 49.

15. Urban Research Development Corporation : "Optimum Recreation Carrying Capacity". Bureau of Outdoor Recreation, USDI, U.S.A., 1977, p. 25.

16. Stankey, G. H., et al : "Human Behavioral Science and Recreation Management". in XVI IUFRO World Congress Div. VI, Oslo, Norway, Proc. IUFRO Secr., Vienna, Austria, June 1976, pp. 53-63.

17. Wang, Hsiao Lin and Yu Feng Ho : "A Study on Ta-Keng Tourism Farm village Planning". (in Chinese), A Report to Taichung City Government, Taichung, Taiwan, ROC, 1989, pp. 79-81.

18. Turoff M., et al., : "The Delphi Method : Techniques and Applications". Addison-Wesley Publishing Company, Massachusetts, U.S.A., 1980, pp. 5-10.

19. Barry Commoner; Sung, Shang Lin (translator): "The Closing Circle". (in Chinese), Ju Liu Book Company, Taipei, ROC, 1974, p.257.

20. Buchwald, K. : "Gedanken Zu Einer Umweltpolitik Fur Die Republik China". Proc. Symp. of Forum on Natural Environmental Planning and Conservation Problems, Taipei, ROC, 1983, pp. 32-33.

21. McHarg, Ian : "Design with Nature". American Museum of Natural History, New York, U.S.A., 1971, pp. 7-17.

22. Berger, Jonathan : "Guidelines for Landscape Synthesis : Some Direction - Old and New". Landscape and Urban Planning, Vol. 14, No. 4, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1987, pp.295-311.

23. Nerikar, Vasant N. : "Gauging Florida's Carrying Capacities by : root count, water seep, humus depth, leaf litter, soil density, plant diversity". Landscape Architecture, The American Sociey of Landscape Architects, Washington, D.C., U.S.A., March 1976, pp. 133-137.

24. Chen, Chih Wu : "An Introduction of an Ecological Planning and Design Method". Bulletin of Environmental Studies, National Taiwan Univ., Taipei, ROC, Vol. 1, No.1, 1981, p. 143.

25. Bunka, Kenchiku : "Ecological Planning : Its Method and Application". 1975, pp.48-164.

26. Hwang, Fu Szu : "Discussion on Environmental Planning Structure". (in Chinese), Chan's Pub. Comp. Ltd., Taipei, ROC, 1982, pp. 71-77.

27. Buchwald, K. : "Aims and Methods of Ecological Planning: Strategies for the Realisation of an Optimal Combination of Land-Uses". Nanyang Univ., Singapore Symposium on "Our Environment". Singapore, 1978. p. 58.

28. Wang, Hsiao Lin : "A Report to the Landscape Planning for the Third Nuclear Power Plant Site and Its Surrounding Areas". (in Chinese), A Report to Taiwan Power Company, Taipei, ROC, 1985, pp. 47-56.

29. Wang, Hsiao Lin, et al., : "A Study on Landscape Planning for the Third Nuclear Power Plant Site and Its Surrounding Areas". (in Chinese with English abstract), J. of the Landscape Architects Society, Taipei, ROC, 1986, pp. 55-66.

30. Wang, Hsiao Lin : "A Study on Landscape Planning and Design for the First Nuclear Power Plant Site". (in

Chinese), A Report to Taiwan Power Company, Taipei, ROC, 1986, pp. 29-37.

31. Wang, Hsiao Lin : "A Study on Landscape Planning and Design for the Shen-Aoh Electric Power Plant Site". (in Chinese), A Report to Taiwan Power Company, Taipei, ROC, 1987, pp. 27-33.

32. Wang, Hsiao Lin : "A Study of the Ta-Keng Hillside Housing Estate Development Models in Taichung". (in Chinese), A Report to Taichung City Government, Taichung, Taiwan, ROC, 1988, pp. 17-25.

CHAPTER 4

MEASUREMENT AND EVALUATION OF RECREATION CARRYING CAPACITY

4.1 Introduction

From the discussion in Chapter 2, we know that with the growth of an economy, the social structure and life styles also change. As leisure time increases, the demand for every kind of recreation activity increases day after day. In Taiwan, this has caused much over use of the natural environment of recreation areas and has led to resource destruction. From the discussion in Chapter 3, we know that the existing planning methods and concepts either based on ecology or sociology have their main concerns. But, they have ignored the carrying capacity of the recreation resource which is very important to keep the environmental quality of a recreation area and the recreational quality for tourist in a certain level.

In this chapter, recreation carrying capacity is defined and the theory used as a basis to mark out how recreation carrying capacity is used in this study. Then the factors that affect recreation carrying capacity are discussed. Last, different methods of measurement of recreation carrying capacity are analysed and evaluated as a basis for setting up criteria as use in the study.

4.2 Theoretical Discussion of Recreation Carrying capacity

The theory of recreation carrying capacity was first introduced by Lapage (1963).[1] He proposed that recreation carrying capacity should include aesthetic and ecological carrying capacities. The former is concerned with the development of recreation uses, providing most users with a satisfactory recreation experience. The latter indicates that use and development of a recreation area should allow the maintenance of the natural environment while providing the user with a satisfactory recreation experience. Wager subsequently published "The Carrying Capacity of Wildlands for Recreation",[2] in which he discussed the recreation carrying capacity in much greater detail. He defined recreation carrying capacity as that optimal use of a recreation area that can be maintained with a long term recreational quality level.

In view of the many terms, several of which appeared in many of the carrying capacity studies. Chubb and Ashton (1969) classified the terms into two main categories and defined them as follows:[3]

Category I: Spatial capacity, further divided by time:

1. Momentary Spatial Capacity: Indicates the maximal number of recreational user-units that can be contained in a moment of time.

2. Daily Spatial Capacity: Indicates the momentary spatial capacity multiplied by the number of use-

frequencies per day.

3. Annual Spatial Capacity: Indicates the spatial capacity multiplied by the number of use-days per year.

This definition considers the spatial idea on the basis of social factors and tourist psychology. It ignores the factors of ecological tolerance.

Category II: Carrying capacity, which is divided into

1. Average Daily Recreation Carrying Capacity: Indicates the number of user-units permissible in a use-day.

2. Annual Recreation Carrying Capacity: Indicates the average daily recreation carrying capacity multiplied by the number of use-days in a year.

The definition of recreation carrying capacity above, which includes natural environmental tolerance, user satisfaction, psychological and social factors, and time factors is comparatively complete. Further clarification of the definition is important to the future study of recreation carrying capacity.

Lime and Stankey (1971) stated that recreation carrying capacity was a characteristic of a recreation area under a definite degree of development in a definite period of time, maintaining a certain level without causing unacceptable damage to the area either on the environment[4] or on tourists' enjoyment. Further, they stated that recreation carrying capacity should include three basic elements: (1) management objective, (2) tourists' attitudes and (3) effects on physical resources. This point of view contributed a great deal to the study of recreation carrying capacity.

In 1977, the United States Bureau of Outdoor Recreation (BOR) integrated all the past studies and defined recreation carrying capacity as a use level. Within this level not only the resources are maintained but also the tourists are satisfied. Therefore, recreation carrying capacity includes physical-ecological carrying capacity and social-psychological carrying capacity.[5] The BOR listed and explained the affecting factors on carrying capacity, and at the same time, provided a set of rational guidelines for planners and managers to use.

Subsequently, studies about the recreation carrying capacity of an area are based on the theories of Lime and Stankey as well as BOR.

The definition of recreation carrying capacity used in the present study is the capacity of a recreation area, under the requirements of the management objective, which provides sufficient recreational quality and opportunity, within the planned time limit, and which is tolerant of the amount of recreation use without causing an unacceptable change, either on natural recreation resources or on tourists' experiences. Recreation carrying capacity should be evaluated according to three main items: (1) management objective, (2) physical-ecological carrying capacity and (3) social-psychological carrying capacity. They are explained below:

1. Management objectives

Different objectives allow different levels of recreation experience and quality. The affecting factors considered have different weighted indices. Therefore, in the evaluation of the recreation carrying capacity of an area, ascertaining the management objective is the first step.

Generally, a management objective has two aspects:[6] The first is the objective in general. Because recreation planning is also part of a comprehensive national plan, the plan should correspond with other land uses when making a planning objective. Its position in the comprehensive national development plan and the recreation system plan must be accordingly observed to ascertain the degree of resource development or conservation. However, this sort of objective is too generalised and can not serve as a basis to ascertain recreation carrying capacity.

The second aspect of a management objective is the objective with clear definition. It mainly describes what environmental state the expected site is to be maintained and what kind of opportunities can be provided to tourists. Its contribution to the future development of the site are made comparatively clear and can be used as the basis to ascertain recreation carrying capacity.

As there are different types of recreation resources, their recreation demands, the recreation experience that they afford and management direction are all quite clear. They form the central contents of the management objective. Therefore, the resources of an area should be sorted according to types, so that the objective can be defined accordingly. Only when the objective has been defined do physical-ecological conservation quality and social-psychological demands have a direction to follow and the evaluation of the total recreation carrying capacity have substantial meaning.

2. Physical-Ecological Carrying Capacity

Physical-ecological carrying capacity represents an optimum level of recreation use. Under this use-level the natural resources of a recreation area can be maintained without suffering irreversible changes.[7] Since the ecosystem is in a state of dynamic balance, any introduced activity will make a change on the present status and cause a new balance. Thus the existence of the natural environment itself has provided humans with opportunities. At the same time, natural environment is able to withstand the pressures which are produced after human activities and use. If a balance between natural resources and human use can be achieved, then the use of natural resources can last continuously, while a balanced ecosystem can be maintained. However, if before the time needed for self-regulation, another activity or use intrudes, then the ecosystem can not be kept in balance. Its balance point will alter gradually, which means that the environmental quality level gradually drops because of overuse or misuse.

3. Social-Psychological Carrying Capacity

Social-psychological carrying capacity indicates the use-capacity which is provided with the object of rendering a specified model and quality of recreation experience to enable tourists to obtain the highest degree of satisfaction.(8) From the analysis of recreation experience quality, the study of social-psychological carrying capacity can be classified into four types:(9)

(1) Satisfaction Model

The discussion focus on the relationship between tourist satisfaction and tourist density. The results show that there is no absolute relation between the two.

(2) Perceived Crowding Model

This is aimed at the discussion of the relationship between tourist density and the perception of crowdedness. The results show that the perception of crowdedness is generally affected by tourist density as well as by other variables, such as expectation, preference, past experience and devotion to the recreational activities.

(3) Perception of Resource Impacts

The main discussion is directed to tourists' perceptions of the resource which is affected because of providing recreational use. The results show that (a) the tourists' perception of the impact is a factor in determing the degree of tourist satisfaction. After the tourists' perception of the resource impacts, different responses often occur. (b) Tourists' perceptions of both crowdedness and resource impact probably are related to each other, no matter what the causality between them is. Following an increase in the number of tourists, the perceptions of both crowdedness and resource impact increase accordingly. The quality of recreation experience is also affected.

(4) Adjustment of Behaviour

This mainly discusses the relationship between tourist transference and crowding perception. In this case, transference means that if tourists are not satisfied with a particular recreation area, then they can visit a different area to seek a more meaningful recreation experience. It is used to identify the processes of behavioural adjustment. The results show that tourist transference and crowding perception that are in complete disagreement.

From the discussion above, this study takes the perceived crowding models as the factors to be considered in determing social-psychological carrying capacity.

4.3 Affecting Factors of Recreation Carrying Capacity

The evaluation of recreation carrying capacity is mainly carried out by determing both the physical-ecological and social-psychological carrying capacities. Therefore, every factor that affects the two becomes an important factor of consideration for the evaluation of recreation carrying capacity of an area.

4.3.1 Affecting Factors of Physical-Ecological Carrying Capacity

The factors of recreational activities which affect physical-ecological carrying capacity can be grouped into two types:

(1) Natural factors: physical-ecological carrying capacity changes as nature changes. These changes are very complex. As they are not the main subject of this study, they are not discussed in this paper.

(2) Manmade factors: physical-ecological carrying capacity changes because of the effect of human factors. The literature shows that the recreational activities which affect physical-ecological carrying capacity mainly include.[10]

(a) Soil: including soil density, organic matter, nutrients, humidity, temperature, soil erosion and soil drainage.

(b) Plants: including changes in vegetation cover, plant composition, plant diversity, plant growth, age structure, mechanical damage, invasion of foreign species and extermination of rare species.

(c) Water: including growth of aquatic plants; and waterborne diseases and water pollutants.

(d) Wild animals: including habitat and intrusion to habitat; changes in population, changes in numbers and kinds of components.

(e) Effect of wastes on the sanitation of the site: including size of the site, area wastes treatment facilities and their condition and accessibility.

(f) Air and geology.

4.3.2 Affecting Factors of Social-Psychological Carrying Capacity

The affecting factors of recreational activities on the social-psychological carrying capacity can be grouped into five classes:[(11)]

1. Psychological factors of tourists

(1) Demand: including recreational motivations, goals, demands and expectations.

(2) Perception: including previous experiences, interest, preferences, perceptions, sensitivity and value judgements.

(3) Background: including educational level, family background, social background, cultural background, age and gender.

2. Social environmental factors of the recreation area

This includes the number of tourists, frequency in which tourists encounter each other, size of the tourist group encountered, observed behaviour of the tourists, homogeneity of the tourist groups, time and spatial dispersion of the tourists.

3. Natural environmental factors of the recreation area

This includes environmental characteristics, scenery, size of the site, environmental vulnerability, limitations of the environment, environmental cleanliness and sanitation, noise, quantity of recreation facilities and their convenience, type and appearence, and traffic conditions.

4. Recreation activity factors

This includes types and quantity of recreation activities, suitability of facilities; and basic requirements, either in quality or quantity; degree of limitation suffered in the course of activities; recreation costs and time needed; and safety of the recreation activities.

5. Other factors

There are activities that cannot be finished in time when weather worsens, accidental events and other unknown factors happen.

4.4 Methods of Measuring Recreation Carrying Capacity

It is obvious from the above discussions that the study of recreation carrying capacity has received a great deal of attention since the 1960s. The main point of the studies has centred on the ecological point of view and has focused on discussions and recreation use which create conflicts with the physical ecology. The emphasis has been on ecological conservation and protection. After the 1970s, the most emphasised subject has been the recreation experience. However, the idea of environmental conservation and protection of the 1960s still has been kept as a theme. These methods frequently have been discussed and analysed in the literature. The following outlines the major methods of measuring recreation carrying capacity that are used as references for this study.

4.4.1 <u>Economic Profit Analysis Method</u>

This method was used by Fisher and Krutilla (1972) to determine the recreation carrying capacity of wild lands, using economic theory.(12) It was assumed that the tourist group was homogeneous and their pursuance of the wild land experience was mainly because of "loneliness". Therefore, the number of persons encountered during the course of an experience was the index of satisfaction which was measured as the value of the "willingness to pay".

This method, although, considered both the price of the ecological environmental damage and recreational satisfaction. It is too simplified for tourist recreation experience. It is also worth arguing if the satisfaction only measured by willingness to pay.

4.4.2 Matrix Analysis Method

Tivy (1972) thought that the concept recreation carrying capacity was extremely complex and suggested a method of matrix analysis for its determination.[13] Her evaluation index is mainly based on site deterioration in quality and the major elements considered include (1) number of tourists decreased, (2) size of area needed, (3) lowering of recreational quality, (4) decrease in other land area usability, (5) effects of use on the ecological environment and (6) increase in conflicts or decrease in competitiveness between activities.

From the analysis results, we can learn the degree of impact of the expected activities acting upon the existing environmental character and the priority and feasibilities of the recreational activities on the site. The factor index used in the matrix analysis method is in detail. It uses all the different recreational settings to set up the different criteria, but it must use some other study results as the basis for objective evaluation in the matrix analysis so that it can be used by managers and planners directly.

4.4.3 System Simulation

Hammon, et al. (1974) used system theory to determine the recreation carrying capacity of lakes.[14] In the formulation, he employed levels and rates of use-units and the factors which affect the two for simulation. The level is the number of use-units (eg. humans, cars) of any area that was occupied in the system in a moment of time. The rate is the number of use-units that flow through the system in a time-unit. Other affecting factors are management policy, lake status and the conditions of tourist use. All these factors have to be quantified.

System simulation method takes into consideration time factors which the other methods do not deal with and is able to use quantification to show causalities. Nevertheless, in setting up the model, it is often restricted by staff shortages, finance, time and data. Unless the data can be easily obtained and are operated by computers, it is difficult to carry out.

4.4.4 <u>Bureau of Outdoor Recreation (B.O.R.) Method</u>

This was a method for the measurement of recreation carrying capacity used by the Urban Research and Development Corporation in the United States, in 1975, under the consignment of the B.O.R. to evaluate all recreation resources, and to provide a set of indices suitable for recreation resource conservation and tourist satisfaction.[15] Its survey and research methods include:

(1) Taking the suitable type of recreational activity of every state of the USA as the basis for setting up the criteria of the measurement of recreation carrying capacity.

(2) Visiting recreation planners and managerial personnel to understand the actual situation of crowdedness and over-use; thereby, in correspondence with the character of recreation resources.

(3) Using this index to evaluate each recreation area; and further, to adjust the carrying capacity.

This method, after the affecting factors and evaluation index have been established, is used to measure the recreation carrying capacity of each area. But this kind of index is not easily established. Even the derived evaluated values of the main affecting factors are only rated into three classes: plus, minus and zero. This causes the method to be less accurate and discriminating between the classes.

4.4.5 Map Overlay Method

Jaakson, et al. (1976) ascertained the environmental carrying capacity of every district of Emma Lake, Canada, through map overlays.[16] Through this method, whether or not each of the areas was overused, could be clearly analysed. But the ecological carrying capacity is only one effect level of recreation carrying capacity. So, a combined consideration which included social-psychological carrying capacity should be exercised for completeness. Moreover, the validity of this method depends on map reading skills.

4.4.6 Expert Committee Method

This method assembles experts from various fields, uses their professional knowledge to recognise effects on the environment and determines their acceptability. It can be classified into two types:

(1) Delphi Method which has been discussed in Chapter 3, Section 3.2.5 of this paper is not repeated here.

(2) Analytic Hierarchy Process Method (A.H.P. Method). This method was initiated by Saaty in 1971. At that time, it was applied to the emergency plan of the Ministry of National Defence, Egypt. By 1974, A.H.P. has begun to be widely used in many fields.[17] Its measurement procedure is based on experts' response to the questions, using a type scale to make pairwise comparisons between affecting factors to establish a matrix and inverse matrix of pairwise comparisons to find a signvector. This vector represents the priority of interaction between factors in a certain hierarchy. From this priority, the sign value is again ascertained and used to test the consistency of every pairwise comparison matrix. If it coincides with the consistency-effect weight, then it can be used as the basis for policy-making. The flow chart of operation is as follows: (Fig. 4.1)

The operation of this method is comparatively complex. However, (1) decision makers can easily express their preference structure; (2) since the measured results possess a relationship of strength, the decision maker can

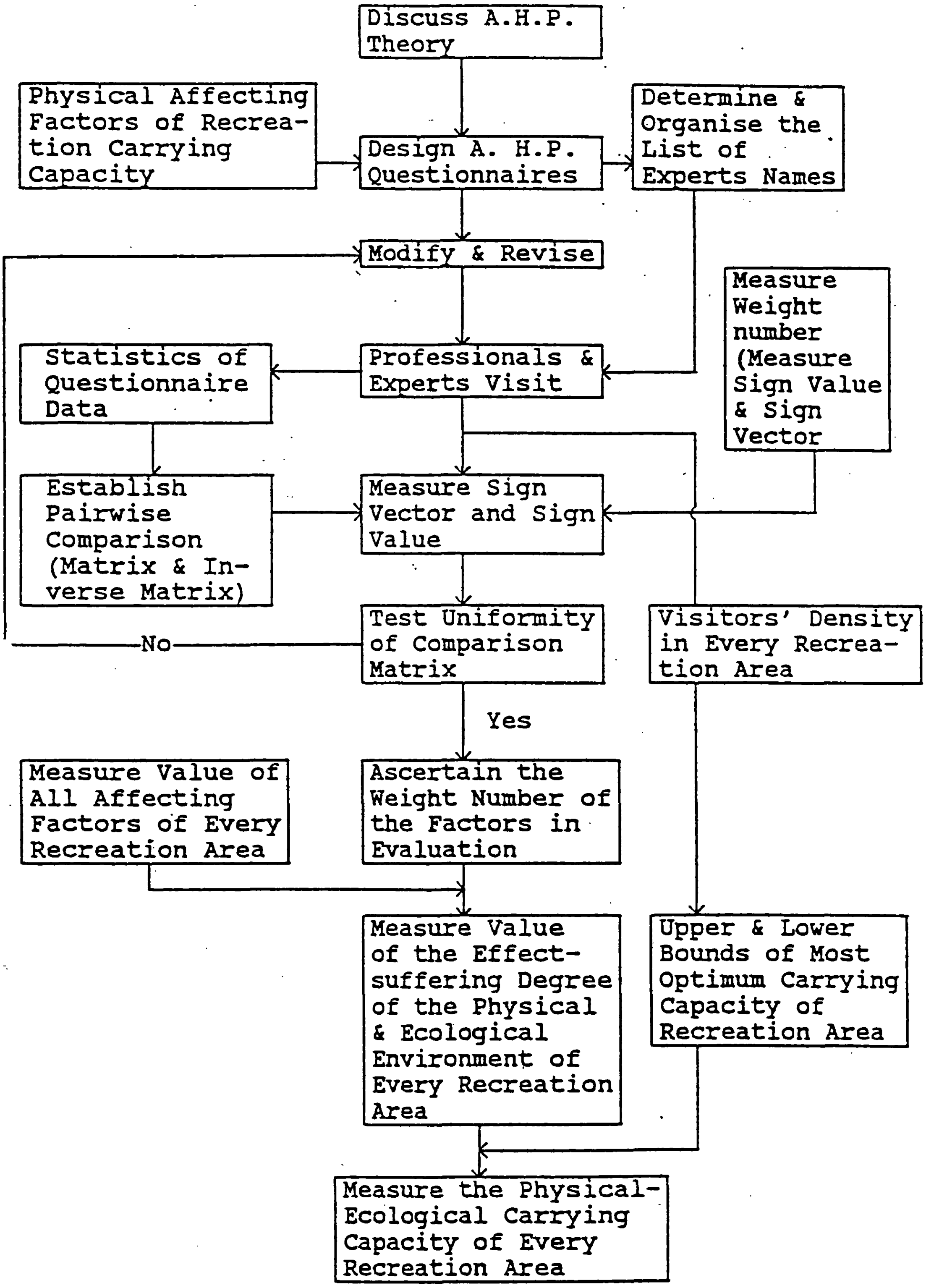


Figure 4.1 <u>Flow Chart for Measuring Physical-Ecological Carrying Capacity by A.H.P. Method</u> (Source: Saaty, 1971)

obtain numerical information from the results; (3) whether decision-maker's preference structure has consistency can be ascertained. Therefore, this study use this method as the basis for measuring physical-ecological carrying capacity.

4.5 <u>Conclusion</u>

From the previous discussions, we know that the main purpose of recreation resource planning and management is, under the premise of maintaining the resources indefinitely, to provide the best recreational quality and experience. And, recreation carrying capacity is the principal factor in maintaining recreation resources and recreation quality.

Recreation carrying capacity must be measured by three factors, the management objective and the physical-ecological and social-psychological carrying capacities. Every affecting factor in an area must be considered and be evaluated through proper methods for the measurement of recreation carrying capacity.

The methods for measuring different recreation carrying capacities have different feasibilities, advantages and disadvantages. The method used in this study to measure physical-ecological carrying capacity is A.H.P., a method which is rather higher in accuracy and comparatively complex in operation. The study uses the concepts of perception of crowdedness and perception of tolerance as basis for measuring social-psychological carrying capacity.

REFERENCES

1. LaPage, Wilbur F. : "Some Aspect of Forest Recreation". J. of Forestry, U.S.A., 1963, pp. 32-36.

2. Wager, T. A. : "The Carrying Capacity of Wildlands for Recreation". For. Sci. Monogr. 7, 1964, pp. 23-39.

3. Chubb, M., and P. Ashton : "Park and Recreation". College of Agr. and Nat. Res., Michigan State Univ. Tech. Rep., No. 15, 1969, p.76.

4. Lime, D. W. and George H. Stankey : "Carrying Capecity : Maintaining Outdoor Recreation Quality". Recreation Sym. Proc., College of Forestry, Syracuse, N.Y., U.S.A., October. 12-14, 1971, pp. 114-184.

5. Urban Research and Development Corporation Bethlehem Pennsylvania : "Optimum Recreation Carrying Capacity." Bureau of Outdoor Recreation, USDI, U.S.A., 1977, pp. 1-18.

6. Dukey, J. W. : "Analytic Techniques in Urban and Regional Planning", 1984, p. 68.

7. Sung, Bin Min : "A Study of Recreation Carrying Capacity Theory". (in Chinese), Unpub. MSc thesis of National Taiwan Univ., Taipei, ROC, 1984, P.32.

8. Lin, Yen Chuo : "A Survey and Report of the Recreation Carrying Capacity of Yu-Shan National Park". (in Chinese), Tung Hai Univ., Taichung, Taiwan, ROC, 1987, pp. 26-131.

9. Graefe, A. R., et al., : "Social Carrying Capacity : An Integration and Synthesis of Twenty Years of Research". Leisure Science, Tayloy & Francis, Washington, D.C., U.S.A., 1984, pp. 395-431.

10. Lucas, R. C. (ed.) : "Proceedings - National Wilderness Research Conference : Current Research". USDA Forest Service Gen. Tech. Rep., INT-212, U.S.A., 1986, pp. 14-23.

11. Wu, Yi Loon : "A Study on the Measurement of Recreation Carrying Capacity for the Camping Sites of Yu-Shan National Park". (in Chinese), Unpub. MSc thesis, Chung Hsing Univ., Taipei, ROC, 1987, pp. 10-14.

12. Fisher, Anthony C. and J.V. Krutilla : "Determination of Optimal Capacity of Resource-based Recreation Facilities". Natural Resource Journal, No. 12, School of Law, Univ. of New Mexico, N.M., U.S.A., 1972, pp. 417-444.

13. Tivy, Joy : "The Concept and Determination of Carrying Capacity of Recreational Land in the U.S.A." Countryside Commission for Scotland, CCS Occasional Paper No. 3, U.K., 1972, pp.5-17.

14. Hammon, G.A., et al., : "Capacity of Water-based Recreation System Part I : The State of Art - a literature review". Water Resources Research, Institute of the North Carolina, U.S.A., 1974, p. 49.

15. Urban Research Development Corporation : "Optimum Recreation Carrying Capacity". Bureau of Outdoor Recreation, USDI, U.S.A., 1977, p. 25.

16. Jaakson, R., Mario D. and D. Botting : "Carrying Capacity and Lake Recreation Planning - A Case Study from North-central Saskatchewan, Canada". Town Planning Review, Vol. 47, No. 4, Liverpool Univ. Press, England, 1976, pp. 359-373.

17. Saaty, T. L. : "The Analytic Hierarchy Process". McGraw-Hill Book Company, N.Y., U.S.A., 1971, p. 2.

CHAPTER 5

THE NEED FOR A SYSTEMS APPROACH

5.1 Introduction

As mentioned in the previous chapter, there are many different ways to deal with recreation resource problems from different points of view. Planners and managers must make compromise decisions, and this always requires some type of model, whether formal or informal.

Management science attempts to resolve conflicts among the components of systems in advance as much as possible. This suggests the application of scientific method to the management of natural recreation resources.

5.2 Towards A Systems Approach

A "system" can be defined as "consisting of a set of elements with relationship between those elements with each element being studied in terms of the part it plays in the system as a whole".[(1)] A systems approach, therefore, develops a manipulated model which will appear to have the same behavioural characteristics as the real system. Meanwhile, the word "programming" in mathematical programming suggests the use of a formalised set of instructions to solve problems. These models may be simple, or they may be complex. But when a mathematical model can be constructed to describe a system with a satisfactory degree of accuracy, then it becomes a convenient, powerful tool for analysis. Such models are easy to manipulate. They provide consistent and precise results, and interactions among variables are readily apparent.

Optimisation is a mathematical process which is used "to find an admissible set of values of the command variable, compatible with the constraints, to maximise the utility function for the given values of the environmental parameters".[2] It involves three steps:

(1) knowing how the system variables interact;

(2) having a measure of system effectiveness; and

(3) choosing values for the variables, so that they yield optimal results.

At the first stage, the planner's knowledge of the system is generated. Then, he has to judge the importance of system effectiveness with selected criteria. Finally, optimisation can be carried out.

Generally, the use of optimisation in planning and management has a number of advantages:[3]

(1) Emphasis is placed on mathematical aspects of planning. Data processing facilities could be used to help in reducing the workload on the planner.

(2) The use of models to understand and predict the behaviour of a system under different conditions provides the planner with a clear picture of activities taking place on channels.

(3) By a combination of (1) and (2) above, the planner is able to achieve an optimal solution.

As mentioned in section 5.1, management science is a science of modelling. There are certain characteristics that make natural resource management problems amenable to analysis by management science. These characteristics are

(1) There are decisions to be made, and the environment in which those decisions are embedded is so complex that intuitive or easily derived solutions are unlikely to provide a sound basis for decision making.

(2) Resources are limited, so that decisions are constrained in some way. Such constraints may be imposed by a wide variety of influences, such as the social need; the amount of money in a budget and the carrying capacity of land, in terms of ecological and sociological aspects.

(3) The facts of the situation can be quantified. Management science makes use of mathematical models, and if it is not possible to develop such a model for a particular situation, then some other mode of analysis will have to be taken.

In general, mathematical programming involves the following:

(1) Using a formalised set of instructions to solve management problems.

(2) A mathematical model can be developed to serve as an abstraction of the system under study. This model

should include some means of evaluating solutions with respect to the optimality criteria (i.e., the objective) and should also ensure that limitations on the availability of resources are observed.

(3) The optimal solution to the mathematical programming problem can be obtained numerically by the execution of an algorithm.

It can be concluded that mathematical programming is concerned with the optimal allocation of scarce resources (e.g., land resources) among competing ends for different purposes of use. Mathematical programming problems are often solved by computers which make the task easier and also permit the analysis of more complex situations.

5.3 The Need for Multiobjective Mathematical Programming (MMP) and Its Application in Natural Resource Management

5.3.1 The Need for Multiple Objective Analysis (MOA)

Many decision problems in natural resource management have multiple objectives. For example, the operation of a multipurpose reservoir may call for delivering irrigation water and supplying electric power to the nearby community, while still trying to maintain minimum water levels in the reservoir itself and downstream to accommodate environmental and recreational goals. Another example is the public forests. Most are also managed for multiple uses, such as timber, water, wildlife and outdoor recreation. These objectives may be conflicting in nature and in trying to satisfy them simultaneouly. But how all these objecitves relate to one another, and how much of each one can be obtained subject to a common set of constraints, can provide resource management with far greater insight into resource operations than that provided by the adoption of a single objective.

Prior to the present era of environmental awareness, our society as a whole placed an overriding priority on the first-order effects of technology and economic growth. Consequently, if there was a conflict between increased electric power production and water-resource development i.e. recreational opportunities on reservoir or along dams, environment protection for wildlife, etc. very likely it would have been resolved in favour of the former.

Societal values and norms are shifting, however, from a position of unchecked economic growth and the acceptance of environmental deterioration to one of concern for the environmental itself, and how it relates to the quality of life.

This shifting of societal values and norms has prompted the enactment of laws regulating the use and management of natural resources with explicit reference to multiple objectives. In turn, the inclusion of multiple objectives in the study of resource-allocation problem has motivated the development of Multiobjective Analysis.[4] New dimensions in the areas of modelling and mathematical programming are generated. The notion of an optimal solution is no longer applicable. Instead, the concept of a set of nondominated solutions is introduced.

5.3.2 Application of Multiobjective Mathematical Programming (MMP) in Natural Resource Management

Multiobjective Mathematical programming (MMP) has been applied in natural resource management since the beginning of the 1970s. It has been used mainly for water resource management, forest resource management, land use planning and outdoor recreation management. In water resource management, Hass (1970) integrated Dantijig-Wolfe's Discrete Algorithm Method into a multilevel approach and applied it to local water resource management. This method has been widely used. Since then, the methods used in multiobjective programming are the greatest in number, and Goicoechea et al. and Haimes have contributed the most. In forest resource management, much attention began to be paid to MMP since Field used Goal Programming to improve forest heredity in 1973. In land use planning there has been much study on land reclamation problems. It has been rarely used in outdoor recreation management. The following (arranged chronologically within each category) described how MMP has been applied to natural resource management:

1. Water Resource Management.

In 1970, Hass first combined Dantijig-Wolfe's Discrete Algorithm and Multilevel Approach and applied the results to regional water quality management. Later, Haimes et al.[5] furthered the study and applied it to the best water quality disposition equipment in one river valley. That was the beginning of multiobjective planning as used in water resource management.

Monarchi, et al. (1973)[6] applied the Sequential Multiobjective Problem Solving Method (SEMOPS) to water resource management of the Bow River Valley of the U.S. After continuous mutual communications and operations with decision makers, the information needed by the decision makers was obtained. In the same year, Miller and Byers[7] used the composite trade-off function to evaluate a water resource plan in which economic effects and environmental quality are in mutual conflict.

The Surrogate Worth Trade-Off Method (SWT method) was first introduced by Haimes, et al. (1974)[8] to solve noncommensurable multiobjective functions in water resource systems. The Reid and Vemuri multiobjective problem was successfully solved via this method. Three objectives were considered: (1) minimum planning cost, (2) minimum evaporation loss, and (3) maximum water capacity.

A study of the Charleston watershed in Southern Arizona, conducted by Goicoechea, et al. (1976),[9] investigated the potential of several watershed management options via Tradeoff Development Method (TRADE). Five purposes were considered: (1) increasing water runoff, (2) increasing recreational benefits, (3) maintaining wildlife levels in the area, (4) increasing commercial benefits, and (5) controlling sediment yield. In 1977, Cooperative n-person game theory was used by Fronza, et al.[10] to establish yearly contract volumes in the operation of Lake Maggiore reservoir in northern Italy.

Tauxe, et al.[11] applied multiobjective dynamic programming to the operation of Shasta Reservoir in California, in 1979. Three objectives were considered: (1) maximisation of cumulative dump energy generated above the level of firm energy, (2) minimisation of the cumulative evaporation or loss of the resource, and (3) maximisation of the firm energy.

In a case study of western Skane in Sweden, Hashimoto[12] (1980) considered local groundwater and two pipeline systems to supply five municipalities. The STEM method was used to obtain tradeoffs among five objectives pertaining to lake water levels, downstream releases and operating costs. Duckstein and Opricovic applied multiobjective optimisation to the design of a water resources system in the Central Tisza River Basin in Hungary.[13] The Tehebycheff Approach has been used by Greis, et al.[14] for the multicriteria analysis of water allocation in a river basin.

Shamir, et al. published "Optimal Annual Operation of a Coastal Aquifer" (1984).[15] In this research, an optimal annual operation of a coastal aquifer was determined by using a Multiple Objective Linear Programming (MOLP) model based on a multicell model of the aquifer and a network representation of a hydraulic distribution system. Four objective functions were based on (1) the desired groundwater surface map, (2) the desired location of the sea water-fresh water interface toe in each coastal cell, (3) the desired concentration map of a selected conservative contaminant, and (4) minimising of the energy for pumping and recharge. The model was applied to a segment of the coastal aquifer in Israel.

An optimisation approach which combines two-dimensional convective-dispersive transport simulation, nonlinear optimisation and sensitivity theory was used by Ahlfeld, et al. (1988)[16] to analyse alternate hypothetical remediation strategies at a Superfund Site in Woburn, Massachusetts. Their theory was that after water became polluted, the ground water could be drawn out and clean water to control the motion of polluted water. That study established a cubic equation and was corrected into a quadratic equation through a simplified process.

2. Forest Resource Management.

Forest management has been aimed mainly at timber production in the past. Since the 1970s, however, because of the changes in environmental management and for the purposes of satisfying changes in public demand, the operation of public forestry in virtually every country in the world has begun to apply the principle of multipurpose use as its main objective. The one who first applied MMP to forestry management was Field (1973) who introduced Goal Programming (GP) to the forestry profession and applied it for the improvement of timber heredity.[15] In 1974, the U.S. Forest Service published a GP Manual,[17] in which Lee's computer programme was used to instruct users on how to prepare the computer input data card and to explain the output results. The following year, Flick,[18] using input-output analysis, established forestry multiobjective use management to handle many kinds of activity problems and to evaluate many feasible plans.

Steuer and Schuler (1978)[19] applied a combination of linear programming and vector-maximum techniques to prepare a preliminary management plan for the Mark Twain National Forest in Missouri. Goal targets were specified in the analysis for the objectives of timber production, dispersed recreation, hunting forest species, hunting open land species and grazing. Duckstein and Gershon (1981)[20] used the ELECTRE II method for analysis of vegetation management alternatives.[14] Five levels of conversion from timber to grasslands were evaluated against criteria that included recreation, water supply, flood damage, forage, timber and maintenance costs.

3. Land Use Planning.

A concordance-discordance approach was used by Nijkamp and Vos (1977)[21] to evaluate alternative land reclamation projects for the Markerward area in the Netherlands. Evaluation criteria were related to additional agricultural, recreational and residential areas; additional employment, increased accessibility, relative importance of a new airport, number of bird species preserved in case of no reclamation and investment costs.

A mathematical programming model was used by Bammi and Bammi (1979)[22] to prepare a comprehensive land use plan for Du Page County, Chicago, that considered multiple objectives and satisfied growth constraints. Multiple objectives and constraints on desired growth patterns were considered simultaneously in arriving at optimal acreages. The objectives were minimising of (1) conflict between different land uses, (2) travel distance of new trips to the existing transportation network, (3) tax costs, (4) adverse environmental impact and (5) capital costs of community facilities. Goicoechea, et al. (1979)[23] applied the PROTRADE method to the reclamation of lands in the Black Mesa region of northern Arizona. The land uses considered included agricultural, recreational, grazing and fish-pond harvesting.

Szidarovszky and Bogardi (1980)[24] used multiple dynamic programming to control the influence of underground water to mining exploration area. A trade-off was achieved for the goals of economic benefit, water supply and environmental quality. Gilbert, et al. (1985)[25] attempted to locate potential sites for a 13-acre residential development within a 2250-acre study area near Norris, Tennessee, by a multiobjective discrete optimisation model. The objectives considered in the allocation were cost, proximity to desirable and undesirable land features and the topography of the area.

4. Outdoor Recreation.

With the growth in recreation demand and use has come the realisation that visitor traffic has strained both manmade facilities and natural systems. Penz (1975)[26] suggested the use of a linear programming model to investigate long-range visitor admittance policies. The constraints of the model express capacities for both manmade facilities and ecological criteria as a function of visitor requirements.

Antle (1979)[27] examined recreational use of the Mclelan-Kerr Arkansas River Navigation System and its impacts on employment, incomes, economic employment and migration in the region.

The application of MMP in natural resources management, as mentioned above, is summaried below.

Table 5.1 Applications of Multiobjective Mathematical Programming in Natural Resource Management

WATER RESOURCES

		Method	Purpose
1970	Hass, J. E.	Discrete Algorithm Method of Dantijig-Wolfe + Multilevel Approach	Regional water resources management.
1973	Monarchi, D. E. Kisiel, C. C. Duckstein, L.	SEMOPS	Water resources management of Bow River Valley , USA.
1973	Miller, W. L. Byers, D. M.	COMPOSITE TRADE-OFF FUNCTIONS	Water resources management
1974	Haimes, Y. Y. Hall, W. A.	SWT	To solve water resource multi-objective problems of the Reid & Vermuri
1976	Goicoechea, A. Hansen, D. R. Duckstein, L.	TRADE	Charleston watershed management of San Pedro River Basin.
1977	Fronza, G. Karlin, A. Rinaldi, S.	N-person Game Theory	To establish yearly contract volumes in the operation of Lake Maggiore Reservoir in n.Italy.
1979	Tauxe, F. W. Inman, R. R. Mades, D. M.	Multiobjective Dynamic Programming	Operation of Shasta Reservoir in California
1979	Goicoechea, A.	PROTRADE	To solve the reclamation of land disturbed by coal strip mining ac-

			tivities in the Black Mesa region of n. Arizona
1979	Das, P. Haimes, Y. Y.	SWT	Development of Maumee River Basin
1980	Hashimoto, T.	STEM	To obtain trade-offs among five objectives for W. Skane in Sweden
1980	Duckstein, L. Opricovic, S.	SWT	Water resource planning of the central Tisza River Basin in Hungary
1983	Greis, N. Wood, E. F. Steuer, R. E.	Tehebycheff Approach	To analyse the water allocation in a river basin
1984	Shamir, U. Bear, J.	MOLP	Optimal annual operation of a coastal aquifer in Israel
1988	Ahlfeld, D. P. Mulvey, J. M. Pinder, G. F.	2-Dimensional Convective-Dispersive Transport Simulation + Nonlinear Optimisation Sensitivity Theory	To analyse alternate hypothetical ground water remediation strategies at a Superfund Site in Woburn, Mass.

<u>FOREST RESOURCES</u>

1973	Field, D.	G.P.	Improvement of timber quality
1974	US Forert Service	G.P.	G.P. manual
1975	Flick, W. A.	Input-output Analysis	To estblish forest resource management model
1978	Steuer, R. E. Schuler, A. T.	L.P. + Vector-maximum Techniques	To prepare a preliminary management plan for the Mark Twain National Forest in

			Missouri

LAND USE PLANNING

1977	Nijkamp, P.	Concordance-Discordance Approach	To evaluate alternative land reclamation projects for the Markerwaard area, Netherlands
1979	Goicoechea, A. Duckstein, L. Fogel, M. M.	PROTRADE	The reclamation of land in the Black Mesa region of n. Arizona
1980	Szidarovszky, F. Bogardi, I.	Multiobjective Dynamic Programming	To search for a control strategy useful in the regional development of a ground water system affected by coal exploration in Hungary
1985	Gilbert, K. C. Holmes, D. D. Rosenthal, R. E.	Multiobjective Discrete Optimisation Model	To locate potential sites for residential development within a study area near Norris, Tennessee

OUTDOOR RECREATION

1979	Antle, L. G.		To examine recreational use of the McClelan-Kerr Arkansas River Navigation System

5.4 Multiple Objective Linear Programming (MOLP)

5.4.1 Background

From the discussion above, we know that mathematical programming in the field of management science has already become a widespread management tool. However, in practical application, in earlier times, they were focused on a single objective problem. Near the end of the 19th century, there were scholars who had discussed problems of this field. In 1896, an economist, Pareto, proposed the concept that "the solution of the multiobjective problem is a nondominated solution". But at that time there was no one who brought forward a method for the solution. It was Kuhn and Tucher (1951), who proposed sufficient and essential conditions of the nondominated solution. Many of scholars subsequently developed a method of solving Multiobjective problem.[28]

5.4.2 Choice of MOLP

A wide variety of methods for mathematical programming with multiple objectives, or multiple objective decision making are available to develop alternative feasible plans. In the traditional theory of Single Objective Function, a decision maker is no longer needed once the objective function and limited clauses are found. An analyst, it is assumed, fully understands the preference structure of the decision maker--which can not be changed. Then the optimal solution is obtained through mathematical programming and proposed to the decision maker. This means that the decision maker participates no more in the process of decision making once the objective function is found. He either accepts the final result or turns it down.

However, solving problems with multiple objective methods often fails to provide an optimal solution that satisfies every goal set. Therefore, the meaning of the preference structure of the decision maker plays a very important part in the process and a satisfactory solution is not possible until the decision maker has finished estimating and comparing.

Perhaps it is sensible to choose the methods for mathematical programming with multiple objectives based on the preference information given to the analyst by a decision maker. Four categories are classified as follow:[29] (Fig. 5.1)

(1) No Prior Articulation of Preference Information

The methods following this approach (Fig. 5.2) do not need any inter-objective or other subjective preference information from the decision maker once the problem constraints and objectives have been defined. Thus this approach requires that the decision maker be able to accept the solution obtained from the method. The advantage of this route is that in the process of obtaining the solution the decision maker will not be disturbed by the analyst, which may be preferable from the point of view of the decision maker. But a major disadvantage then is the necessity for the analyst to make many assumptions about the decision maker's preferences. This is difficult to do with even the best and most knowledgeable analyst.[30] Global Criterion Method is an example of this category.

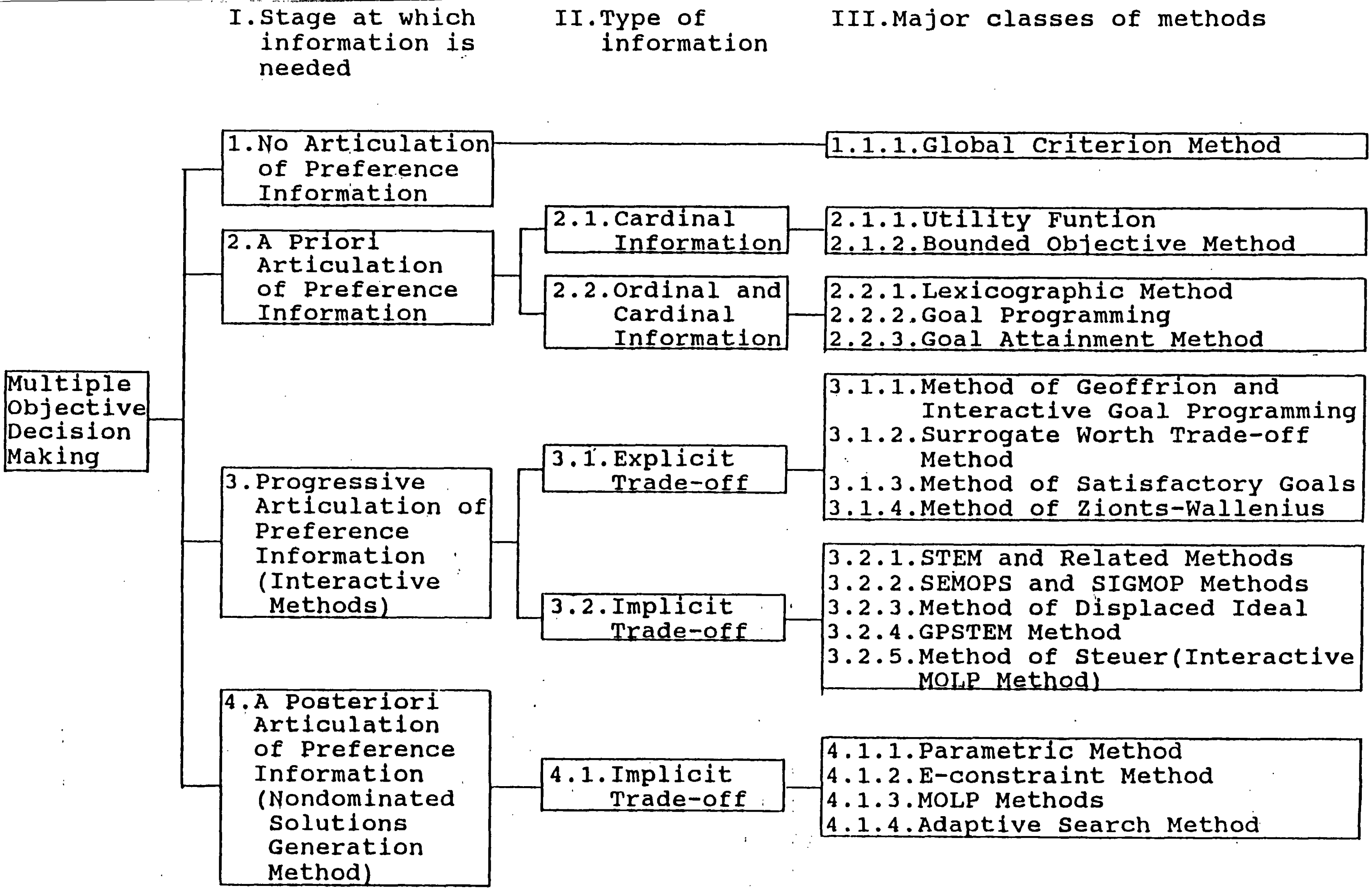


Figure 5.1 A Taxonomy of Methods for Multiple Objective (Source: Hwang, et al, 1980)

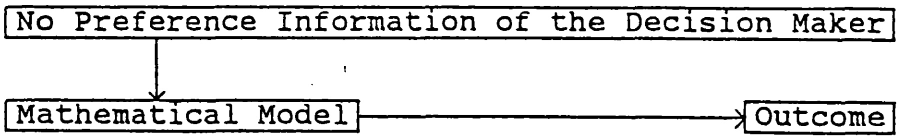


Figure 5.2 Schema for Solving Multiple Objective Function Using No Prior Articulation of Preference Information (Source: Hemming, 1978)

(2) Prior Articulation of Preference Information

In this method (Fig. 5.3) the decision maker's preference information is acquired before the analyst conducts the problem solving. This means that the decision maker gives every objective function a subjective weight or a certain level of satisfaction to some specified objective function value. The disadvantage of this method is that the decision maker cannot modify the preference structure once it is confirmed. Goal Programming is an example of this category.[31]

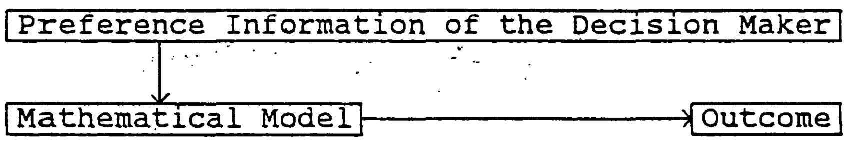


Figure 5.3 Schema for Solving Multiple Objective Function using Prior Articulation of Preference Information (Source: Hemming, 1978)

(3) Progressive Articulation of Preference Information

This method is commonly known as the Interactive Method. (Fig. 5.4) The decision maker is not able to provide any prior preference information, due to the complexity of the problem. Thus he gradually modifies his current solution through dialogues with the analyser. The advantages are (a) prior preference information of the decision maker is not needed; (b) the decision maker comes to better understand the problem and the process acts as a learning process; (c) only local preference information is needed; (d) with the decision makers' active participation, the case stands a better chance of succeeding and smoother. The disadvantages are (a) The result depends heavily on the accuracy of the decision maker's local preference information; (b) There is no guarantee of a satisfactory solution with limited runs; (c) More time and effort is required of the decision maker. Surrogate Worth Trade off Method is an example of this category.[32]

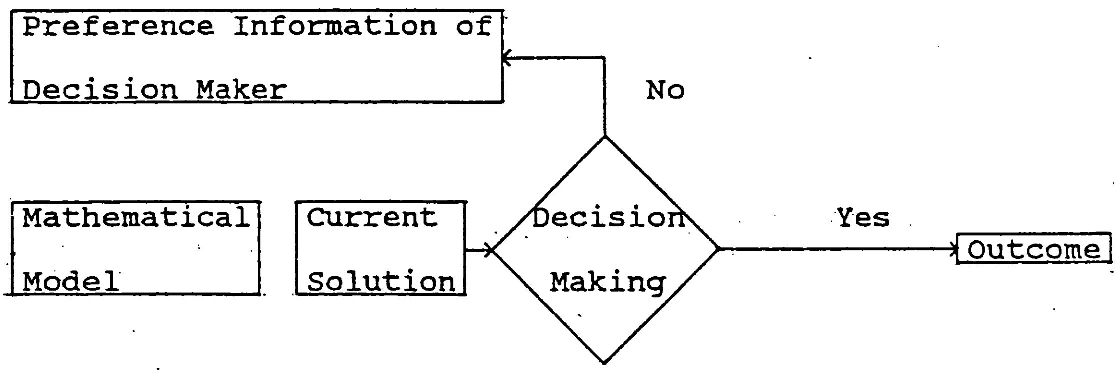


Figure 5.4 Schema for Solving Progressive Articulation of Preference Information

(4) Posterior Articulation of Preference Information.

The method determines a subset of the complete set of nondominated solutions to the vector maximal problem. From this subset the decision maker chooses the most satisfactory solution, making implicit trade-offs between objectives based on some previously unindicated or nonquantifiable criteria. In any case, the trade-off information is received from the decision maker after the method has terminated and the subset of nondominated solutions has been generated. (Fig. 5.5) The advantage is that there is no need to establish a decision maker's efficient function.[33] But, a learning process is adopted in the course of decision making. Multiple Objective linear Programming (MOLP) is an example of this category.[34]

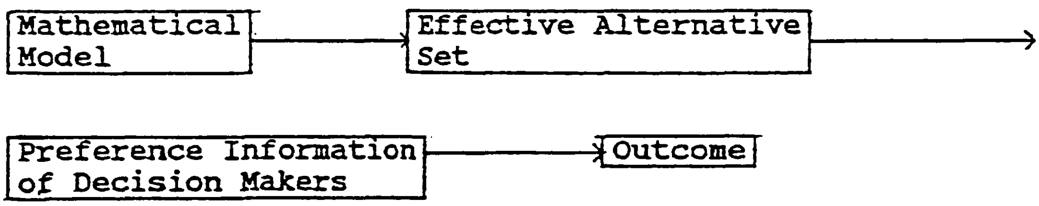


Figure 5.5 <u>Schema for Solving Posterior Articulation of Preference Information</u>

It is obvious that decision makers play an important role in multiple objective analysis. However, for the no prior articulation method, the analyst has to make many assumptions about the decision maker's preferences which is very difficult. For the prior articulation method, once the decision maker's preference structure is fixed, there is no way to correct it. Consequently, this method can not undertake a compromise operation and so reduce the inside conflict of the decison maker. The third method--progressive articulation--provides more participation opportunities for decision makers and is the better model for correcting the preference structure. But, much more effort is required of the decision maker than is so with methods presented previously. The fourth method--posterior articulation finds a set of effective alternatives for the decision maker to evaluate and compare, so to select the best.

The major target of planning and management of natural recreation resource is how to satisfy multiobjective demands under the constraints of limited resources, while those objectives are often set up at mutual conflict value judgements. It is possible to cast the recreation resource management plans as multiple objective linear programming problems to suffer minimum loss on every side and achieve a satisfactory solution.

5.4.3 Formulation of MOLP

Multiple Objective Linear Programming (MOLP) is the derivation of Linear Programming (LP). It is used to compensate the defects of LP and has been actually practised. The single-objective programming problem consists of optimising one objective subject to a constrant set. While a multiple objective linear programming is characterised by a p-dimensional vector of objective functions. The multiobjective problem is expressed as follows:[34]

$$\text{Max } Z = [Z1(X), \ldots Zi(X)]$$

$$\text{s.t.} \quad x \in S$$

In the above MOLP, a solution $x^E \in S$ is efficient if and only if there does not exist another $x \in S$ such that $Zi(x) > Zi(x^E)$ for all i and $Zi(x) > Zi(x^E)$ for at least one i. That is, $x^E \in S$ is efficient if and only if its associated criterion vector $Z(x^E)$ is nondominated. Their differences are listed in Table 5.2.

Table 5.2 Comparison of LP and MOLP

Type / Comparison	LP	MOLP
Scope of Application	Single Objective	Multiobjective
Solution	Best Solution	Nondominated Solution
Goal-Function	If there is a solution, objective would best reached.	It is not definite that each objective will reach the best. It is a compromised solution.

The general procedure of the formulation of a MOLP consists of the following main steps: (Fig. 5.6)[34]

(1) Prepare a general statement of needs as perceived in the study of the problem at hand.

(2) Define goals and objectives; these should reflect the needs stated above and societal values.

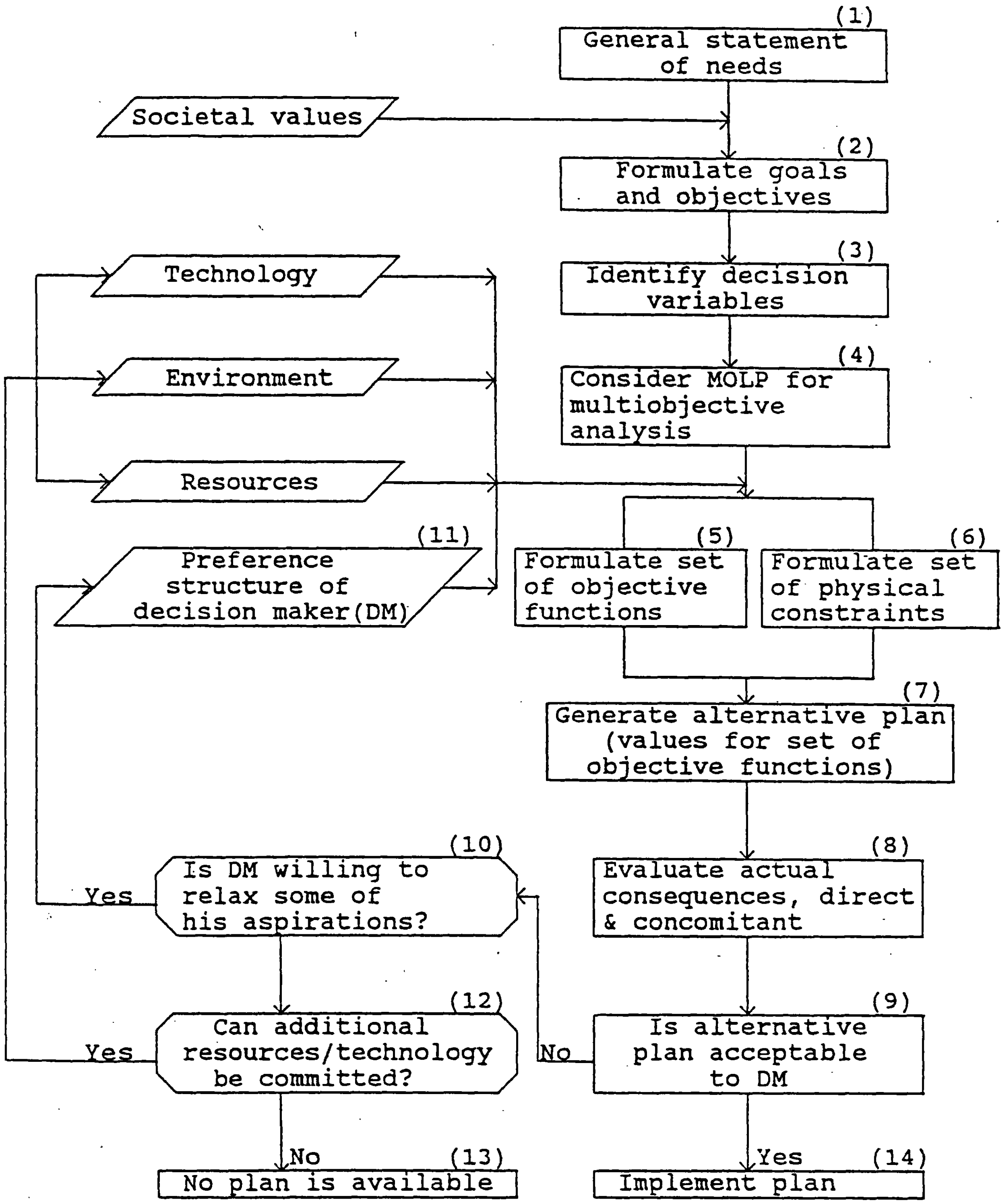


Figure 5.6 The General Procedure of Formulating a MOLP
(Source: Goicoechea, 1982)

(3) Identify pertinent decision variables.

(4) Consider MOLP for multiobjective analysis.

(5) Formulate a set of objective functions. Each function must address one or more of the goals and objectives stated in step (2) above and must be expressed in terms of the decision variables in step (3). Collectively, the set of objective functions should address all the goals and objectives in (2).

(6) Formulate a set of physical constraints. Again, these constraints must be functions of the decision variables and represent limitations on resources available.

(7) Generate an alternative solution (plan). The make-up of this alternative solution is a value attained for each one of the objective functions (i.e., a nondominated solution)

(8) Evaluate actual consequences, direct and concomitant. Once a solution is generated, its consequences can be outlined in terms of actual resources utilised, and how well the goals stated in step (2) are met.

(9) Determine whether the alternative solution is acceptable to decision maker. The decision maker (an individual or group of individuals) responsible for the project is asked to subjectively assess the value of the current solution to him. Values attained for some of the objective functions may be lower than those he may have expected. Proceed to step (14) if affirmative.

(10) Determine whether the decision maker is willing to relax some of his expectations. Here, the decision

maker must ascertain whether he could accept less in some of the objective functions in the hope of receiving more in others and still consider the aggregated value acceptable. If affirmative, proceed to step (11), otherwise proceed to step (12).

(11) Responses are elicited from the decision maker to attempt to establish the relative worth to him of objective function units. Schemes are available to structure these responses into "weights" that now can be incorporated in the mathematical framework to generate another alternative solution.

(12) Determine whether additional resources/technology can be committed. This step asks whether additional resources can be committed to the project, that is, capital, time, manpower, hardware, etc. If affirmative, proceed to step (6), otherwise proceed to step (13).

(13) No feasible plan is available.

(14) Implement alternative solution.

The MOLP model can be solved using the computer programme for the modified simplex alogorithm. The available MOLP computer codes are presented in Table 5.3.

Among the MOLP computer codes, VIG, a computer programme developed to support criteria decision making on an IBM PC/1 microcomputer, supports both modelling and solving decision problems is adopted in this study.

Table 5.3 <u>Available MOLP Computer Codes</u>

Computer Code	Author(s)	Remarks
Steuer(1974)	Adjacent basis[35]	approach interval weights
ADEX	Steuer(1974)[36]	Adjacent efficient extreme point
ADBASE/FILTER	Steuer(1977)[37]	An extension of code 1
MOLP	Iserman(1977)[38]	In Algol language
ADBASE/VMF	Steuer(1984)[39]	Generating all efficient extreme point
VIG	Korhonen and Laakso(1986)[40]	An interactive method

MOLP has been applied in management science since the mid of the 1970's. It has been used mainly for industry management,[39][41][42] commercial foreign exchange forecasts,[43] tree breeding strategy[44] and natural resource management,[15][19] while very rare examples can be found in the management of recreation resource. So it is worth to explore the application of MOLP in the field of natural recreation resource management.

5.5 <u>Conclusion</u>

As discussed above, all existing methods dealing with natural resource management exhibit subjective and narrow points of view. The purpose of this study is to go beyond existing methods and to find the best land use planning method for allocating resources. A comprehensive and systematic approach to tackle this problem is needed.

The advantage of a systems approach is that it provides the opportunity to structure a series of investigations so that results can be obtained--results that meet the objectives.

By using MOLP, a nondominated solution can be obtained. Based on this, decision makers can make rational inferences and judgements. MOLP can provide analysts and decision makers opportunities for practical participation in decision making in the course of proceeding. The only role played by the decision maker is the decision of whether the best feasible solution is wanted or not. It does not require making a compulsory decision on the best feasible solution. This process is not only established and executed by means of a model, but decision makers can also make MOLP play an important role in supporting them in the course of decision making.

(1) MOLP, a popular technique recently developed in the management science area, posseses the function of handling decision problems which deal with multiple, competitive and conflicting objectives, so that a

nondominated solution can be obtained.

(2) MOLP can provide opportunities for practical participation in decision making in the course of the proceedings and support decision makers in playing an important role in the course of decision making. Lastly, a optional decision on the best feasible solution can be reached through the learning process.

REFERENCES

1. Reif, B. : "Models in Urban and Regional Planning". Leonard Hill Books, 1973, p. 5.

2. Apps, P. F. : "Urban Design and the Problem of Evaluation, Social Services in Architecture". Architectural Service Research Unit, Syndey Univ., Australia, 1972, pp. 12-27.

3. Ho, Yu Feng : "Optimum Housing Rehabilitation Plan". Modern Construction of Architecture and Civil Engineering, No. 4, Taipei, ROC, April 1983, p. 77.

4. Dykstra, Dennis P. : "Mathematical Programming for Natural Resource Management". McGraw-Hill Book Company, N.Y., U.S.A., 1984, p. 230.

5. Haimes, Yacov Y., Kaplan, M. A. and M.A. Husar : "A Multilevel Approach to Determining Optimal Taxation for the Abatement of Water Pollution". Water Resources Research (84). A merican Geophysical Union, washington, D.C., U.S.A., 1972, pp. 851-860.

6. Monarchi, D. E., Kisiel, C. C., and L. Duckstein : "Interactive Multiobjective Programming in Water Resources: A Case Study". Water Resources Research, Vol. 9, No. 4, American Greophysical Union, Washington, D. C., U.S.A., 1973, pp. 837-850.

7. Miller, W. L. and D. M. Byers : "Development and Display of Multiple-Objective Project Impact". Water Resources Research, Vol. 9, No. 1, American Geophysical Union, Washington, D. C., U.S.A., 1973, pp.11-20.

8. Haimes, Y. Y. and W. A. Hall : "Multiobjective in Water Resource Systems analysis : The Surrogate Worth Trade off Method". Water Resources Research. Vol. 10, No. 4, American Geophysical Union, Washington, D. C., U.S.A., 1974, pp. 615-620.

9. Goicoechea, A., Duckstein, L. and M. M. Fogel : "Multiobjective Programming in Watershed Management : A Case Study of the Charleston Watershed". Water Resources Research, Vol. 12, No. 6, American Geophysical Union, Washington, D. C., U.S.A., 1976, pp.

1085-1092.

11. Tauxe, F. W., Inman, R. R. and D. M. Mades : "Multiobjective Dynamic Programming with Application to a Reservoir". Water Resources Research, Vol. 15, No. 6, American Geophysical Union, Washington, D. C., U.S.A., 1979, pp. 1403-1408.

12. Hashimoto, T. : "A Multiobjective Approach to Allocating Water Resources for Municipal, Agricultural and Recreational Uses". Working Paper WP-80-107, International Institute for Applied Systems Analysis, Laxenburg, Austria, June, 1980.

13. Duckstein, Lucien and Servafim Opricovic : "Multiobjective Optimization in River Basin Development". Water Resources Research, Vol. 16, No. 1, American Geophysical Union, Washington D. C., U.S.A., 1980, pp. 14-20.

14. Greis, Noel P., Wood, Eric F. and Ralph E. Steuer : "Multicriteria Analysis of Water Allocation in a River Basin : The Tehebycheff Approach". Water Resources Research, Vol. 19, No. 4, American Geophysical Union, Washington, D. C., U.S.A., 1983, pp. 865-875.

15. Shamir, U., Bear, J. and A. Gamliel : "Optimal Annual Operation of a Coastal Aquifer". Water Resources Research, Vol. 20, No. 4, American Geophysical Union, Washington, D.C., U.S.A., 1984, pp. 435-444.

16. Ahlfeld, David P., Mulvey, John M. and George F. Pinder : "Contaminated Groundwater Remediation Design Using Simulation, Optimization, and Sensitivity Theory". Water Resources Research, Vol. 24, No. 3, American Geophysical Union, Washington, D. C., U.S.A., 1988, pp. 443-452.

17. U. S. Dept. of Agriculture, Forest Service : "Goal Programming Manual." Forest Service Eastern Region Milwaukee, Wisc. U.S.A., 1974, p. 45.

18. Flick, Warren A.: "Resource Flows and Values". USDI, Bureau of Land Management Tech. Note 276. U.S.A., 1975.

19. Steuer, R. E. and A. T. Schuler : "An Interactive

Multiple-Objective Linear Programming Approach to a Problem in Forest Management". Operations Research, Vol. 26, No. 2, The Operations Research of America, Baltimore, U.S.A., 1978.

20. Duckstein, L. and M. Gershon : "Multobjective Analysis of a Vegetation Management Problem Using ELECTRE II". Working Paper 81-11. Univ. of Arizona, Tucson, U.S.A., 1981.

21. Nijkamp, P. and J. B. Vos : "A Multicriteria Analysis for Water Resource and Land Use Development". Water Resources Research, Vol. 13, No. 6, American Geophysical Union, Washington, D.C., U.S.A., 1977.

22. Bammi, D. and D. Bammi : "Development of a Comprehensive Land Use Plan by means of a Multiple Objective Mathematical Programming Model". Managemnt Science Interfaces, Vol. 9, No. 2, Pt 2, The Institute of Management Science, Providence, U.S.A., February, 1979.

23. Goicoechea, A. : "Multiple Objectives Under Uncertainty : An Illustrative Application of PROTRADE". Water Resources Research, Vol. 15, No. 2, American Geophysical Union, Washington, D.C., U.S.A., 1979, pp. 203-210.

24. Szidarovszky, F. and I. Bogardi : "Dynamic Multi-objective Control of Mining, Water Supply and Environmental Effects". Working Paper No. 80-1, Dept. of Systems and Industrial Engineering Univ. of Arizona, U.S.A., 1980.

25. Gilbert, Kenneth C., Holmes, David D. and R. E. Rosenthal: "A Multiobjective Discrete Optimisation Model for Land Allocation". Management Science, Vol. 31, No. 12, The Institute of Managemnet Science, Providence, U.S.A., 1985, pp. 1509-1522.

26. Penz, A. J. : "Outdoor Recreation Areas: Capacity and the Formulation of Use Policy". Management Science, Vol. 22, No. 2, The Institute of Management Science, Providence, U.S.A., 1975, pp. 139-147.

27. Antle, L. G. : "Recreation at the McClelan-Kerr Arkansas River Navigation System". Water Resources

Bulletin, Vol 15, No. 5, American Water Resources Association, Bethesda, U.S.A., 1979.

28. Hemming, T. : "Multiobjective Decision Making Under Certainty", EFI, Stockholm, 1978, p. 57.

29. Hwang, C. L., Paidy, S. R. and K. Yoon : "Mathematical Programming with Multiple Objectives : A Tutorial". Computers and Operations Research, Vol. 7, Pergamon Press. In., Exeter, England, 1980, pp. 6.

30. Ibid 28, p. 7.

31. Charnes, A. and W. W. Cooper : "Goal Programming and Multiple Objective Optimasation-Part 1". European Journal of Operational Research, Vol. 1, No. 1, Elsevier Science Publisers, B. V., Amsterdam, The Netherlands, 1977, pp. 39-54.

32. Haimes, Y. Y. and W. A. Hall : "Multiobjective in Water Resources Systems Analysis : The Surrogate Worth Trade-Off Method". Water Resources Research, Vol. 10, No. 4, American Geophysical Union, Washington, D.C., U.S.A., 1974, pp. 620-624.

33. Gal, T. and J. Nedoma : "Multiparametric Linear Programming". Management Science, Vol. 18, No. 7. The Institute of Management Science, Providence, U.S.A., 1972, pp. 406-421.

34. Goicoechea, A., et al., : "Multiobjective Decison Analysis with Engineering and Business Applications". John wiley, New York, U.S.A., 1982, pp. 9-23.

35. Steuer, R. E. : "ADBASE: An Adjacent Efficient Basis Algorithm for Solving Vector Maximum and Interval Weighted-Sums Linear Programming Problems". (in FORTRAN), Abstract in J. Marketing Res., No.12, 1975, pp. 454-455.

36. Steuer R. E. : "ADEX : An Adjacent Efficient Extreme Point Algorithm for Solving Vector-Maximum and Interval Weighted-Sums Linear Programming Problems (in FORTRAN)", SHARE Program Library Agency, Distribution Code 360D-15.2.014.1974.

37. Steuer, R. E. : "Operating Manaual for the ADBASE/FILTER Computer Package for Solving Multiple Objective Linear Programming Problems. (Release : 5/78), College of business and Economics, Univ. of Kentucky, No. BA7, 1977, pp. 5-18.

38. Isermann, H. : "The Enumeration of the Set of All Efficient Solutions for a Linear Multiple Objective Programm". Operations Research, Quart., Vol. 28, No. 3, The Operations Research of America, Baltimore, U.S.A., 1977, pp. 711-725.

39. Steuer, R. E. : "Sausage Blending Using Multiple Objective Linear Programming". Management Science, Vol. 30, No. 11, The Institute of Management Science, Providence, U.S.A., November 1984, pp. 1376-1384.

40. Korhonen, P. and Laakso, J. : "A Visual Interactive Method for Solving the Multiple Criteria Problem". European Jouranl of Operational Research, Elsevier Science Publishers, D. V., Amsterdam, The Netherlands, 1986, pp. 277-287.

41. Kannanen, Ilkka et al., : "Multiple Objective Analysis of Input-Output Models for Emergency Management". Operations Research, Vol. 38, No. 9, The Operations of America, Baltimore, U.S.A., March-April, 1990, p. 193.

42. Lawrence, K. D. et al., : "Aggregate Industrial Expansion : A Multiple Objective Linear Programming Formulation" Engineering Economist, Vol. 25, No. 3, American Society for Engineering Education and American institute of industrial Engineers, Inc., Norcross, U.S.A., Spring 1980, pp. 197-207.

43. Kwok, C. C. Y. et al., : "Composite Foreign Exchange Forecasting to Managers of Multinational Corporations". Management International Review, Vol. 28, No. 19, Bertelsmann Publishing Group International Taunusstr, Germany, October 1988, p. 15.

44. Matteiss, T. H. et al., : "A Tree Breeding Strategy Based on Multiple Objective Linear Programming". Interfaces, Univ. of Alabama Vol. 14, No. 5, U.S.A. Sept./Oct. 1984, pp. 96-104.

CHAPTER 6

THE RECOMMENDED METHOD

6.1 Introduction

From previous discussions, we understand that there are various methods for the planning and management of recreation resources. Some of the methods are based on a sociological point of view, some others are based on ecological conservation. But none are able to offer as much support as can the quantification of land use planning. As for recreation carrying capacity, there are no useful guides as to how to make good use within an acceptable range of limited land resources. It follows that the feasibility of researching recreation resource land use by applying a mathematic model is assured. In this chapter, a systems approach is proposed for recreation resource planning and management. This method uses Landscape Ecology Planning Method (see Chapter Three, Section 3.3.3) as its basic theoretical structure; and with reference to physical-ecological and social-psychological carrying capacities, as well as cost-benefit analysis, it thus simultaneously covers the sociological, ecological and economic domains.

6.2 Considerations and Assumptions of the Recommended Method

As the most directly prescriptive space form is based on the land-use plan of a recreation area in terms of the use of recreation resource. The general objective of planning and management is to propose a method for land development. A comprehensive land use plan for recreation resources includes many quantitative and non-quantitative factors. The concept of the most suitable land use model design is to define the various activities in a certain area. It includes a study of optimisation that searches for a solution under constraints, and an optimal solution to effectively utilise scarce land resources.[1] In this section, general considerations and assumptions of the recommended method are explained.

1. The method, by combining Landscape Ecology Planning Method and MOLP, analyses, evaluates and synthesises ecological, sociological and economic planning factors. From the method, a number of plans can be projected for the decision maker to select. Therefore, in the process of developing the method, planning factors should, at the same time, be taken into consideration.

2. In the land use plan of a recreation area, the recreation carrying capacities of the various land uses of each subzone of the recreation area should be ranked as important factors. It should be measured individually according to different recreation activities.

3. The number of tourist visits fluctuates, owing to unexpected political, social or economic factors, such as governmental policy or inflation. Therefore, the number

of tourists at each particular recreation area must periodically be counted, so that the various recreation activities and facilities can be adquately reviewed; and so that the ecological balance and recreation quality can be maintained.

4. The purpose of recreation resource planning and management in this study is to find a model that best facilitates environmental quality, offers the greatest possible number of recreation opportunities and achieves optimal financial planning for recreation resource.

5. It is proposed to search for the land area of various types of recreation activity in this study. Therefore, the functions and physical characteristics of each recreation activity, and the site characteristics that go with each activity, must be thoroughly perceived.

6. In order to simplify the model in practice, and make the functioning of the recreation activity more complete, the miscellaneous facilities of the major recreation activities should be included as part of the project area.

7. The land use types in individual planning zones are classified according to the planning objectives and the need to simplify the contents of the model.

8. Land which is not part of the recreation area - it

may be urban development land -- is not included in this study.

6.3 Establishing the Planning Method

The theoretical structure of the recommended method is mainly based on the Landscape Ecology Planning Method.[(2)] Combined with the concept of recreation carrying capacity and cost-benefit analysis, and theoretical basis of the MOLP, this method expects to achieve, by choice of the decision maker, a satisfactory land-use plan of a recreation area. Theoretical concept of the recommended method is explained.

Landscape Ecology Planning Method as Basic Planning Structure

Overall review of the existing planning theories and methods shows that there are two types of methods : sociological and ecological. The study chooses Landscape Ecology Planning Method as basic planning structure for the four key issues which are adopted in the methods:

1. The environmental conservation of natural resource.

Natural recreation resources possess the characteristics of nonrenewability and nonrestorability. Most of these characteristics reflect the vulnerability of nature which needed to be protected and preserved. Thus through improper use or over use by humans, natural resources suffer damage or destruction, even threatening to perish from the earth. Therefore, in the use of resources, it is only under the premise of maintaining a balanced relationship between human and resources that the recreation quality and contiuning of the recreation resources could be maintained.

2. The optimal use of the resources.

Each single resource of an area has the potential for development. The level of development is determined by the potential of the resource. They should be neither overused or underused. Only if a balanced relationship between human beings and resources is maintained, the recreation quality and continuity of the resources can be pursued.

3. The maintenance of landscape quality.

There is a close relationship between the use of resource and the maintenance of the landscape quality of a recreation area. A visual impact to the environment may be caused by the improper use of the resources. A visual analysis should be undertaken to find out the visual impact so that a strategy to reduce the problem can be generated.

4. The application of systematic analysis.

Three subsystems that contain resources, users and management are included in the recreation system of a recreation area. Through the interaction of the subsystems, the optimal use of the resources can be achieved. A recreation area includes various kinds of recreation resources and human activities, it is a complicated system with correlated factors. Changes in any one factor may produce a series of changes or a total effect on the whole system. This suggests the application of scientific method to the management of natural recreation resources. Landscape Ecology Planning Method is made up of steps and techniques. It is a study of all alternatives that can reach the objectives. Through a given evaluation process, results are provided to decision makers as reference. Besides, an analysis process is carried out by means of computer package and operation.

However, there are problems to be solved and factors to be considered. Such as some parameters are not completely quantified; and in the planning process both recreation carrying capacity and economic factors are neglected. A brief discussion of recreational carrying capacity concept and cost-benefit analysis and their application on this study are made.

Recreation Carrying Capacity and Cost-Benefit Analysis as Planning Concepts

Recreation carrying capacity has been defined as the character of use that can be supported over a specific time by an area and developed at a certain level without causing damage to either the physical environment or the experience for the visitor. Rational use of recreation resource, where the most limiting factor, sociological or ecological, is identifiable and appropriate measures are taken to ensure that the effects of recreational use do not exceed the acceptable limits of change for the factor.

Researchers did much to more develop the concept, identify the major component, and measure specific parameters, including social-psychological and physical-ecological carrying capacities as discussed in Chapters Three and Four. While, planners and managers believed the issue of overuse in natural areas involved escalcating demand for a finite resource base, they sought recreation carrying capacity that associate demand for recreation with the capacity and limitation of the resource base. Besides, in outdoor recreational setting, capacity can be expressed in design units, such as camping spaces or picnic tables, where recreation carrying capacity is used to express design unit. Recreation carrying capacity has become a widely accepted management concept in dealing with the problems of managing recreation areas. Therefore, the study adopts recreation carrying capacity to Landscape Ecology Planning Method as sociological and ecological planning indicators for the management of recreation resource.

With regard to economics, this study uses cost-benefit analysis in correlation with the development and planning recreation area to find the investment return of each spot expected, under the time frame, in order to properly employ the financial capabilities.

Based on consideration of social-psychological and physical-ecological carrying capacities and investment return, the study obtains sociological, ecological and economic quantified data, so the planning result is more persuasive.

Multiple Objective Linear Programming as Optimisation Technique

A recreation area is a complicated system with correlated factors. Therefore, management of recreation resources usually has multiple purposes. However, these purposes often conflict with each other. It is no doubt, in natural recreation resources management, comprehensive planning of multipurpose uses must be taken into account. The situation cannot be solved with a single-purpose mathematical programming, but must have application to multiobjective mathematical programming.

Multiobjective mathematical programming is one way of considering multiple objectives explicitly and simultaneously in a mathematical programming framework. There are many reasons for the increasing interest in multiobjective mathematical programming. One of them is the increasing recognition that most decision problems are inherently multiobjective. Even many problems addressed by classical single-objective models can easily be viewed as multi-objective in nature. The other reason for increasing interest in MMP is the enormous improvement over the last twenty years in the speed, storage, and flexibility of computing facilities. Algorithms for solving multiobjective mathematical programmes typically require much more storage and CPU time than algorithms that address similar single objective models. In addition, many of multiobjective algorithms require an interactive approach between the decision maker and the computer. These interactive approaches necessitate speedy responses from the computer and flexibility in computing hardware and software.

The problem of multiobjective mathematical programming to be solved is how to satisfy many value-conflicting multiple purposes at the same time under limited resources of the system. After assigning values to the variables, a satisfactory solution for each purpose is obtained. In other words, in multipurpose problems an optimum nondominated solution exists. This indicates that when an objective function decreases, the other objectives increase relatively. The solution obtained by decision makers in multiobjective mathematical programming should be the most satisfactory one.

However, the result obtained might differ because of the effect of the decision maker’s preference structure. In this study, the posterier articulation of preference is used and the non-preemptive goal programming provided by VIG is adopted. A great deal of competitive or complementary objectives, under the operation of the modelling, make a rational coodination. The nondominated solution obtained can provide decision makers with an optional scope for decision making.

In conclusion, recreation resources planning and management, through using mathematical modelling, not only can acquire in a limited time a set of feasible solutions for decision makers to use as reference, but also can quantify basic input information, making the output result have higher accuracy and greater reliability. This can compensate for the deficiency in Landscape Ecology Planning Method. A flow chart of the recommended method is shown in Figure 6.1.

Step 1. Selection and Description of the Project Area

The first step in planning and managing recreation resource is to define the project area. Usually there are two methods for selecting an area. One is that the planner considers the planning and management objectives and selects an area out of several proposed areas. This is an ideal method which better assures the objective. The other method of selecting an area is before beginning the plan.[3] An important point is that an improperly defined area increases the difficulties of planning and management.

The theme of this study explores the planning and management of recreation resources; therefore, the project

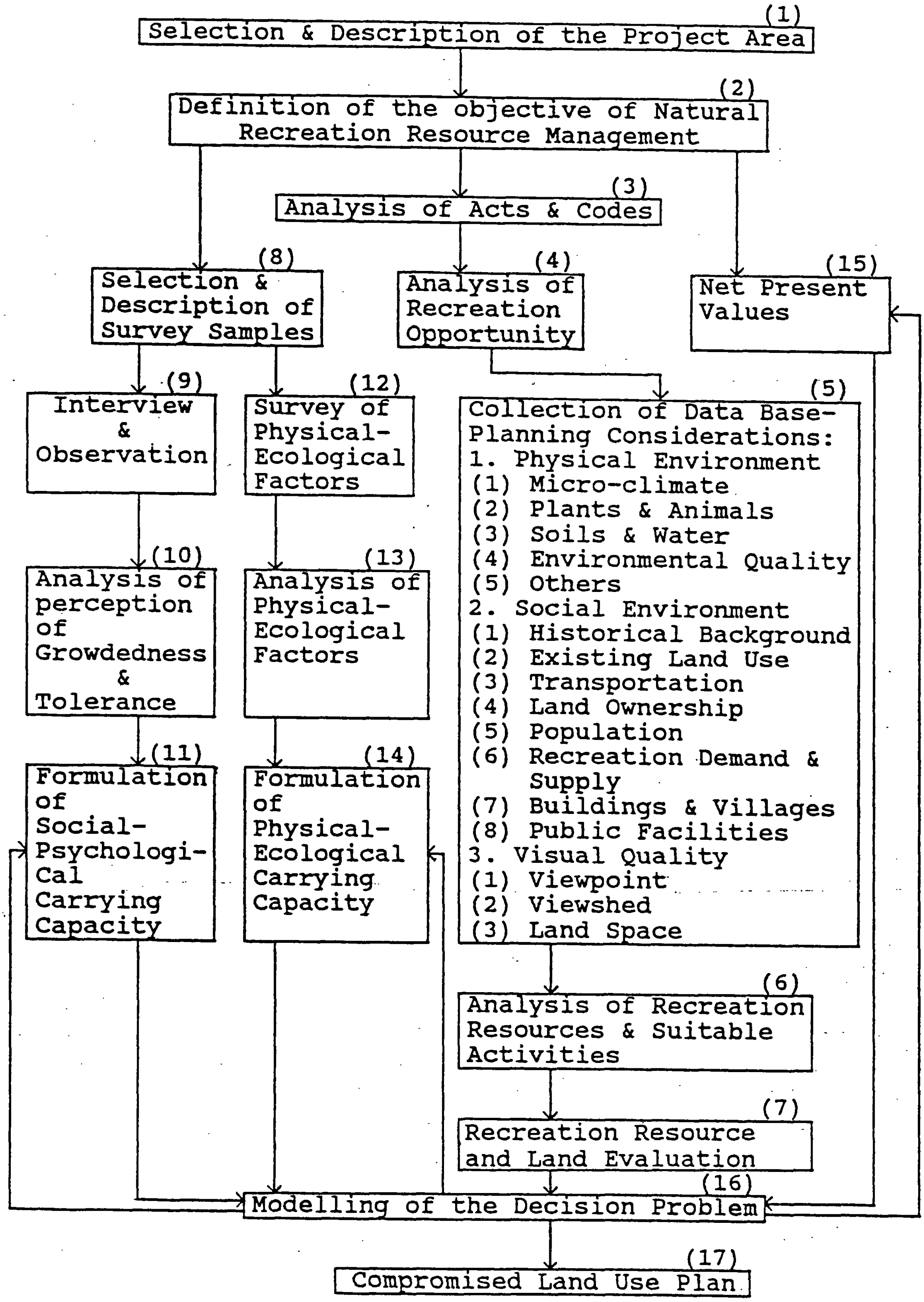


Figure 6.1 Flow Chart of the Recommended Recreation Resource Planning Method

area should possess developed recreation resources or have potentials for recreation development.

When an area is selected and defined, its present status, including the physical environment, social-economic environment, quality of the scenery and other characteristics, should be surveyed and analysed, so it can be used as a reference for the planning and management of recreation resources.

Step 2. Definition of the Objective of Natural Recreation Resource Management

The future land use plan is determined by the management objective of the recreation area. It is vitally important that a clear and definite management objective of the recreation area is defined before the land use plan can be formulated. Based on previous discussions of recreation planning methods and the basic concepts of the recommended method, the objectives of recreation resource management should have as its premise the management of natural resources, while at the same time providing the tourist with the greatest number of recreation opportunities and the most positive recreation experiences; and seek the largest net economic profit, while still fulfilling the premise of recreational need as a social benefit.

Step 3. Analysis of Acts and Codes

Any development project must be processed under official acts and codes with the guidance of a master plan. Thus, at the start of planning, the acts and codes concerning the project area must be thoroughly researched and regarded as the constraints of the planning model.

Step 4. Analysis of Recreation Opportunity

Recreation opportunity is a recreation experience expected by a person when one takes part in a certain recreational activity at certain environmental setting. It is given by a recreation area according to the nature of the site. Since different opportunities can be pursued from different recreation resources. Thus, a higher quality of recreation experience can be obtained by a variety of recreation opportunities provided by the appropriate management. It is necessary to analyse the recreation opportunities of a recreation area in order to propose a guideline for the development of the area. In this study, the research of the characteristics of recreation opportunity is based on recreation opportunity spectrum proposed by Clark and Stankey, in 1979.(4)

Step 5. Collection of Data Base -- Planning Considerations

Recreation resources planning includes both the demand and supply sides. How to direct them to a balanced situation is the main objective of planning. Generally, recreation resources provide recreation activities demanded by people; while the planning of recreation resources aims to supply the various requirement of the recreation activities.

From Chapin's dynamic model of the recreation activity system, (Fig. 6.2)[5] we know that the model of activities is determined by the preferences of the people who participate the activities and the recreation opportunities provided by the resources; while the preferences of participation in activities are determined by participants' characteristics; and the opportunities for participation in the activities are determined by the environmental feasibilities, the facilities available and the environmental quality. Hence, it can be seen that participation in recreation activities is the combined result of tourist demands and the effect of recreation resources supply.

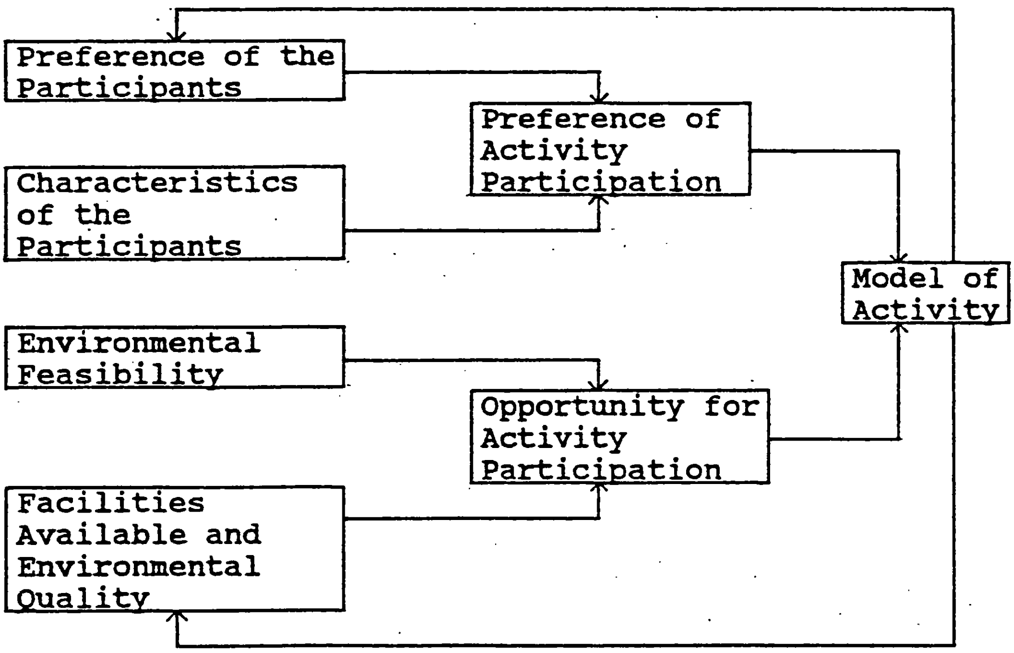


Figure 6.2 Dynamic Model of Recreation Activity System

In the meantime, factors such as historical background, existing land use and land ownership, etc., of a site influence future development of the recreation area significantly. They should be taken into account in the planning of recreation resources. In other words, both social and physical factors must be considered concurrently as far as the management of recreation resource concerned.

Furthermore, visual quality is another factor in planning a recreation area. Analysis of visual quality of viewpoint, area viewed and land space should be included in planning consideration.

Step 6. Analysis of Suitability of Recreation Activities

The understanding of characteristics and suitable activities of the recreation resources of an area helps in evaluating the potential recreation resource land use. According to Chapin's proposal as mentioned above, the model of recreation activities is mainly determined by the preferences of the tourist and the recreation opportunities provided by the resources. On the other hand, a recreation area usually has many different recreation resources. So they should be analysed and classified that the suitable activities of the area can be proposed.

Step 7. Recreation Resource and Land Evaluation

Evaluation of the development potential of an area is the process of estimating the potential of the land for one use or for several possible uses, in terms of either the land's suitability or its capability.[6][7] Having assessed the recreation opportunities and the suitable activities of a recreation area and defined the planning objectives, evaluation of the development potential of the area should be carried out with the ecological conditions of the site. As the result, a clear picture of land-use plan of the area is formulated.

Step 8. Selection and Description of Survey Sample

The number of survey samples depends on the size of the project area, staff, budget and time. If these factors allow, complete data can be obtained by sampling and survey. Alternatively, an investigation of a representative land use activity of the project area and descriptions of the present status of each survey sample should be made. Survey results are to be used as references for measuring the recreation carrying capacity.

Step 9. Interview and Observation

Recreation carrying capacity, as used in this study, is determined by the measurement of physical-ecological and social-psychological carrying capacities of the survey sample areas. Most studies of social-psychological carrying capacity in the past adopted recreation use capacity-measured at the threshold when tourist satisfaction drastically drops -- as the most suitable social-psychological carrying capacity. (Stankey, 1973, 1978)[8][9]

However, there are quite a few factors that affect tourist satisfaction, and they are difficult to measure accurately. Since tourist use capacity gradually increases, the number of tourists who feel crowded will increase as well. When the number of tourists increases to certain peak level of crowdedness, the ratio of tourists who feel crowded and intolerant to those who do not, will also increase rapidly. Hence, this study adopts the perception of crowdedness and perception of tolerance of that peak level to measure and obtain the most suitable social-psychological carrying capacity of each sample area. Tourist satisfaction is in relation to leisure and recreation time, place and types of recreation activity. Social-psychological carrying capacity of each sample area is measured by different activity in different time.

A questionnaire is adopted for interviewing the tourist. While interviewing, the number of tourist groups and tourists are also observed and recorded as a reference for the measurement of social-psychological carrying capacity.

Step 10. Analysis of Perception of Crowdedness and perception of tolerance

The factors that affect the tourist's perception of crowdedness and perception of tolerance, apart from the density of the sample area, include the number of tourist groups and tourists, as well as the tourist's attitude, age and so on, and at the time and place of recreation activity. Thus, to measure the social-psychological carrying capacity of different recreation activity of each sample area, all factors should be taken into consideration.

Step 11. Formulation of Social-Psychological Carrying Capacity

In this study, single item analysis and cross analysis are adopted to the measurement. Detail discussion of analysis is described in Chapter Eight, Section 8.2.1.

Step 12. Survey of Physical-Ecological Factors

From the discussion in Section 4.3, we understand that recreation use can transform the physical environment. The power of transformation depends on time and location and others. Hence, the natural elements (such as soil, vegetation, etc.) in the sample area, that are likely to be affected by activities, should be previously investigated. The investigation results are used as the basic reference to evaluate the impact of the recreation activities on those elements.

Step 13. Analysis of Physical-Ecological Factors

The influence of recreation activities on physical factors is a rather complex matter. It requires long-term observation, experiment, comparison and analysis.(10) This study adopts a more feasible method-the Analytic

Hierarchy Proccss(AHP), as well as the knowledge of experts, scholars and manager to obtain an understanding of the project area. This understanding will help in evaluating the influence of recreation activities on the various elements of the environment of each sample area.

Step 14. Formulation of Physical-Ecological Carrying Capacity

In this study, the Analytic Hierarchy Process Method is adopted to the measurements of physical-ecological carrying capacity of different recreation activity of each sample area.(11) Discussion of the analysis is given in more detail in Chapter Eight, Section 8.3.4..

Step 15. Net Present Value

As recreation resources and their requistic facilities receive investment of both public and private funds, their planning and management must be considered from the economic point of view. At the same time, the objectives of recreation planning attempt to fulfill both individual and social welfare, as well as to maintain ecological balance. For resource oriented recreation activities, the development of recreation areas should be taken into consideration how to minimise the development budget and/or to maximise investment return under the constraints of maximising ecological conservation and recreation demand. In this study, a net present value model is applied. The concept of net present value with reference to planning objectives is discussed in detail in Step 16, modelling of the decision problem, of this chapter.

Step 16. Modelling of the Decision Problem

This study considers that minimum physical-ecological carrying capacity, maximum social-psychological carrying capacity and the investment return are the major objectives of recreation resource management. The objective function and its constraints are explained as follow:

A. Objective Function

1. To minimise physical-ecological carrying capacity

The major goal of a recreation area is to provide recreation opportunities. Yet, the amenities of the physical environment of the scarce recreation resources are often damaged due to overuse. Hence, a recreation area should offer rational recreation use under the premise of preserving natural and manmade resources. The physical-ecological carrying capacity of an area is the density of the tourists of the area capable of bearing the maximal use of the resource wirbout causing the danages of the resource itself. In order to provide the best protection of the resources, it is necessary to keep the tourists devsity under control. Therefore, the objective of planning and management of natural recreation resources seeks the minimum physical-ecological carrying capacity in a limited area. Its objective function is expressed as follow:

$$\text{Minimise} \quad Z1 = \sum_{i=1}^{m} \sum_{j=1}^{n} PECC_{ij} \cdot X_{ij} \quad \ldots\ldots\ldots\ldots(1)$$

where:

$PECC_{ij}$ = physical-ecological carrying capacity of zone i, type j, i.e. subzone(i,j)

X_{ij} = land area of zone i, type j.

2. To maximise social-psychological carrying capacity

The goal of recreation is to allow the tourist to experience the maximum satisfaction from the recreation activities. Hence, not only the particular recreation experience and the quality of that experience, but also the number of tourist of an area and the rate of encounters between individual tourist, will all lead to the increasing perception of crowdedness and the decreasing perception of tolerance and degrees of satisfaction.[(12)(13)(14)]

Sowman(1987) has defined the social-psychological carrying capacity as "the maximum level of recreation use, in terms of numbers and activities, above which there is a decline in the quality of the recreation experience from the point of view of the recreation participation". It is obvious that social-psychological carrying capacity is concerned with a visitor's perception of the presence or absence of other simultaneous utilisation of the resources. Since the social benefit from the utilisation of a recreation resource is to provide the largest numbers of the users with a high quality of recreation experiences.

Thus, the maximal number of the tourists with an acceptable social-psychological carrying capacity should be considered. Its objective function is expressed as follows:

$$\text{Maximise} \quad Z2 = \sum_{i=1}^{m} \sum_{j=1}^{m} SPCCij \cdot Xij \quad \ldots\ldots\ldots \quad (2)$$

where:

SPCCij = social-psychological carrying capacity of zone i, type j

3. To maximise the investment return

In any investment attention has to be paid to the proportion of cost against benefit in order to achieve economy and effectiveness of investment. In cost-benefit analysis concrete and long-term problems are taken into account. In terms of recreation planning, not only is the estimation of the monetary effect in the development addressed, but also the unexpressed positive and negative effects of the project that impose upon the natural enviromment evaluated, to facilitate government and private investments in the construction of recreation establishments.[15]

In cost-benefit analysis all factors are quantified to evaluate the positives and negatives of each alternative. However, most costs and benefits have everlasting characteristics. It requires, therefore, that suitable discount and interest rates have to be chosen and commuted into present value. To measure costs and benefits correctly, effective methods have to be selected first. In this study, a net present value model which is more capable of reflecting time-value is adopted, in order to obtain maximum investment return. That is,

$$\text{Maximise } Z3 = \sum_{i=1}^{m} \sum_{j=1}^{n} aij \quad Xij \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$$aij = \frac{Rtij - Ctij}{(1+r)^{t}}$$

Where Rtij = the return received in year t for each zone i,type j

Ctij = the cost incurred in year t

Rtij - Ctij = net return in year t

r = the rate of discount (%)

Several important issues are further explained as follows:

(1) Present Value (PV)

When considering the capital budget decision making policy, the time value of money has to be examined. However, investors favour present value more than future.[16] The following are the reasons:

a. The methods of using money are different for everyone. A dollar earned today has more value than one earned a year later, because the present one can be reinvested immediately to produce a certain amount of future returns.

b. Futurity includes a certain amount of uncertainty which increases risks concomitant to the time lag.

c. Inflation: the commodity price index continually rises. Deflation is again possible, but people are used to the purchasing power of the dollar today, which will be higher than in the future in any case. The idea of present value can also be applied to the choosing of investment schemes. An investment scheme capable of producing returns today is definitely better than one producing returns later.

(2) Discount

The rate of discount plays a decisive role in cost-benefit analysis. Future benefits and costs of every kind of investment scheme can be compared after being expressed in money and used as the basis for policy-making. But the total costs and benefits of the investment in the present period are the main factors. Thus the rate of discount should reflect the resources used in alternative investments at different times in present value. This effect includes the following points:(17)

a. The greater the discount, the smaller the present value of the net revenue.

b. If the rate of discount is extremely high, the discounted value of the revenue will be negative.

c. The priority of investment schemes is affected by the rate of discount.

d. When the rate of discount increases, the priority of the scheme which has more present benefit will increase.

(3) Determination of the Rate of Discount

In choosing a plan and comparing positive and negative points of different plans, a rate of discount is needed to commute costs and benefits to present value. In determining the rate of discount, it theoretically is better to reflect the consumption ability and investment risks.(17)

(4) Rate of Return

Profit is not only the original impulse for economic activity, but also an important source of investment. Scholars have different views on profit. Frank H. Knight thinks that profit is the reward for risk-burden.(18) In this study, risks are classified as high, average and low.

This study selects from the above the proper viewpoints for application and objectively considers each factor to achieve a rational management plan for recreation resources. The concept and application of net present value on case study is discussed in Chapter Nine in details.

B. Constraints

The constraints of the above multiobjective function include

(1) the total planning area

In the management of recreation resource, both the supply of the resources and the demand of the users have to be considered simultaneously. The development of the recreation resources of a recreation area must be limited to the amount of land available to avoid excessive use of land resources. Thus, the development is constrained by the land limitation for alternative uses. The constraint can be formulated as follows:

$$\sum_{i=1}^{m} \sum_{j=1}^{n} Xij = T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

(2) the land area of each zone

The development of the land resource of each zone which has the same physical character must be limited to the amount of land available in that zone. The constraint can be stated as follows.

$$\sum_{j=1}^{n} Xij \leq Ti \qquad i=1,\ldots,m \quad \ldots\ldots\ldots\ldots(5)$$

(3) the compatible relationship between different land uses in the same zone

There are different kinds of recreation resources in the same zone of a recreation area. Some of them can stand the recreation uses of the tourists, but some are not. Although it is the planning objective of a recreation area to provide maximal recreation opportunities, there must be a strategy to protect the recreation resources. It is suggested that the land area of the preservation area of each zone must be more than the total area of the other subzone of each zone. The ratio of the land area of the preservation area to the total area of the other subzone depends on the type of the land uses of each zone. The constraint is expressed as follows:

$$X_{ij} \geq G_{ij} \sum_{j' \in J} X_{ij'} \quad \begin{matrix} i=1,\ldots,m \\ j=1,\ldots,n \\ j \neq j' \end{matrix} \quad J \subset \{1,\ldots,n\} \ldots (6)$$

(4) the equating needs for different land uses

It is the planning objective of a recreation area to make the maximal use of land and the resources, in order to make the maximal benefit from investment. On the other hand, a higher recreation quality cannot be achieved without the provision of the public facilities. Thus, it is necessary to consider the following constraint.

$$\sum_{i=1}^{m} d_j \; X_{ij} \leq F_j \quad j=1,\ldots\ldots,n \ldots\ldots\ldots(7)$$

(5) Constraints of the total budget

The capital allocated to the development of each zone must be limited to the cash budget. The constraint is expressed as follows:

$$\sum_{j=1}^{n} C_{ij} \, X_{ij} + FC_i \leq C_i \quad i=1,\ldots,m \ldots.(8)$$

(6) Nonnegative constraints

The land area of each subzone must not be negative.

$$X_{ij} > 0 \quad \begin{matrix} i=1,\ldots\ldots,m \\ j=1,\ldots\ldots,n \end{matrix} \ldots\ldots\ldots(9)$$

where: X_{ij} = the land area of zone i, type j.

T = the total area of the planning area

T_i = the total land area of zone i.

G_{ij} = the compatible relationship between ratio of subzones j in the same zone i.

dj = the service coefficient of land development.

Fj = the total area of land use of type j.

Cij = the unit-cost of zone i, type j.

FCi = the fixed cost of zone i.

Ci = the total cost of zone i.

Step 17. Compromised Land Use Plan

This study solves multiobjective criteria problems through the operation of a model developed to aid the decision maker. The model is solved by a software package, VIG.[19] The final result obtained from evaluation and calibration of the model is a compromised land use plan.

6.4 Conclusion

The recommended method considers social, ecological and economic factors of natural recreation resource management simultaneously and applies a MOLP model for analysis. In comparison with the existing methods discussed in Chapter Three, the recommended method has the following advantages:

1. In multiobjective management of natural recreation resources, an account of the entire planning of multiobjectives use should be made. The recommended method is based on the concept of systematic analysis, integrating recreation carrying capacity and investment return to Landscape Ecology Planning Method, with

application of a MOLP model fo analysis. As a result, a rational management plan of recreation resource can be attained. Thus, the method is comprehensive in recreation resource management.

2. In the process of planning, affecting factors are analysed and synthesised to evaluate land suitability. Data of land use, physical-ecological and social-psychological carrying capacities, as well as the investment return are computed and put into the model. Several alternatives are generated. Then, the decision makers can use Pareto Race of a software package, VIG, to search an efficient frontier and find the best solution. Thus, this method does not only have a clear flowchart but also has quantifiable data for analysis, which is the common defect of the existing methods. Hence, the recommended method is comparatively objective and reliable.

3. Among various mathematical methods for land use analysis, MOLP is able to take many objectives into consideration at one time, to analyse a problem as a whole, to provide several compromised solutions for decision makers' evaluation. In the meantime, the DM can evaluate the values of the objectives by pay-off analysis. Hence, this method is rather flexible and selective.

4. Computer techniques are used for both analysis and synthesis of survey data, and implementation of model. The

recommended method is valid and has potentiality in natural recreation resource management.

REFERENCES

1. Wilson, A. G. : "The Aim of Urban Land Use Plan Design is the Optimisation of the Use of Land Space". 1974, p. 19.

2. Wang, Hsiao Lin : "A Study on Landscape Planning for the Third Nuclear Power Plant Site and Its Surrounding Areas". (in Chinese with English abstract), J. of the Landscape Architects Society, Taipei, ROC, 1986, pp. 55-66.

3. Wang, Hsiao Lin : "Landscape Planning and Design For Housing Estate". Taiwan Architechtural Information Semimonthly, Taipei, ROC, 1983, pp. 53-60.

4. Clark, R. N. and G. H. Stankey : "The Recreation Opportunity Spectrum : A Framework for Planning, Management and Research". USDA Gen. Tech. Rep. PNW-98, U.S.A., December 1979, pp. 23-28.

5. Chapin, F. S. : "Human Activity Pattern in the City". John, Wiley & Sons, Inc., U.S.A., 1981. p. 15.

6. Hammond, C. M. and B. H. Walker : "A Procedure for Land Capability Analysis in Southern Africa, Based on Computer Overlay Techniques". Landscape Planning, No. 11, Elsevier Science Publishers, B. V., Amsterdam, The Netherlands, 1984, pp. 269-271.

7. Young, A. : "Tropical Soils and Soil Survey". Cambridge University Press, London, U.K. 1976, p. 70.

8. Stankey, George H. : "Visitor Perception of Wilderness Recreation Carrying Capacity". USDA Forest Service, Research Paper INT-142, U.S.A., 1973. p. 61.

9. Stankey, George H. et al., : "Wilderness : Carrying Capacity". Wilderness Management. U.S. Forest Service Miscellaneous Pub., No. 1365, Washington, D.C. U.S.A. 1978, p. 23.

10. Lucas, R. C. (ed.) : "Proceedings--National Wilderness Research Conference : Current Research". USDA Forest Service Gen. Tech. Report, INT-212, U.S.A., 1986,

pp.14-23.

11. Saaty, T. L. : "The Analytic Hierarchy Process". McGraw-Hill Book Company N.Y., U.S.A., 1980, p. 2.

12. Shelby, B. : "Social-Psychological Effects of Crowding in Wilderness : The Case of River Trips in the Grand Canyon". 1976, p. 18.

13. Shelby, B. : "Crowding Models for Backcountry Recreation Land Economics". 1980, 56:43-55.

14. Bultena, G. L., et al., : "Closing the Gates : A Study of Backcountry Use-Limitation at Mount McKinley National Park". Leisure Science, No.4, Tayloy & Francis, Washington, D. C., U.S.A., 1981, pp. 249-267.

15. Wang, Pin Long : "Urban Financial Sources Construction Problems Research". (in Chinese) Unpub. MSC thesis of the Graduate School of Finance, Cheng-ta Univ. Taipei, ROC, August 1975. pp. 25-38.

16. Wu, Lo Yuen : "On the Time Value of the Currency." (in Chinese) Finance and Management of China, Taipei, ROC, 1977, pp.35-37.

17. Chang, Kin Yang : "Finance." Wu Nan Publishing Co. Ltd., Taipei, ROC, 1976, pp. 175-176

18. Chen, Se Ming : "Profit Theory Research". (in Chinese) Unpub. MSc thesis of the Graduate School of Economics, Tung Wu Univ., Taipei, ROC, 1977, Chapter II.

19. Korhnen, Pekka J. : "VIG-A Visual Interative Support System for Multiple Criteria Decision Making". Helsinki School of Economics, Finland, 1988, pp. 7-11.

PART TWO : APPLICATION

CHAPTER 7

PLANNING AND MANAGEMENT OF TA-KENG SCENIC AREA

7.1 Introduction

This study is concerned with the formulation and evaluation of management policy for recreation resource. In Part One of this study, some methods of formulation were examined and it was concluded that a systems approach should be introduced. A method which includes a decision model was suggested by using a combined techniques of Landscape Ecology Planning Method and Multiple Objective Linear Programming when the recreation carrying capacity and cost-benefit analysis are taken into consideration in Chapter 6. The decision model was constructed to provide an abstract view of some real characteristics of planning a recreation area.

Part Two of this study deals with the application of the recommended method to illustrate the use of the method. The planning and management of Ta-Keng Scenic Area in Taiwan is considered as a case study. For only a thorough application of a case study can demonstrate the applicability of the method as a useful tool for the manager and the planner. In this chapter, the formalation of a preliminary land-use plan based on the Landscape Ecology Planning Method of the recommended method is discussed.

Ta-keng Scenic Area is located in the northeast of Taichung city. It connects Chung-Hsing mountain range in the north, Tou-ko mountain to the east, Pu-Tzu-Keng river in the south. The preservation area, which is in the master plan of the Taichung city urban plan and the Ta-li stream borders the westside of the scenic area. It totals 3,300 ha in area and is only about 10 Km in distance from the centre of Taichung city. (Fig. 7.1)[1]

As Ta-keng Scenic Area is located in the middle part of the island, it has convenient communication and is one of the largest scenic areas within the bounds of the urban plans of Taiwan. It has a great potential for future development. Therefore, this study uses Ta-keng Scenic Area as the study area.

7.2 Survey and Analysis of Ta-Keng Scenic Area

7.2.1 Physical Environment

1. Topography and Terrain

The altitude of Ta-keng Scenic Area varies from 112m to 858m above sea level, the northeast being higher than the northwest. The greatest relief is 746m. Thus microclimates and scenery vary significantly. (Fig. 7.2) Generally, the mountains and streams run from east to west. There are six streamlets which transversely separate the area into five mountain ridges, much like a palm leaf. (Fig. 7.3) The streamlets form a watershed. (Fig. 7.4)

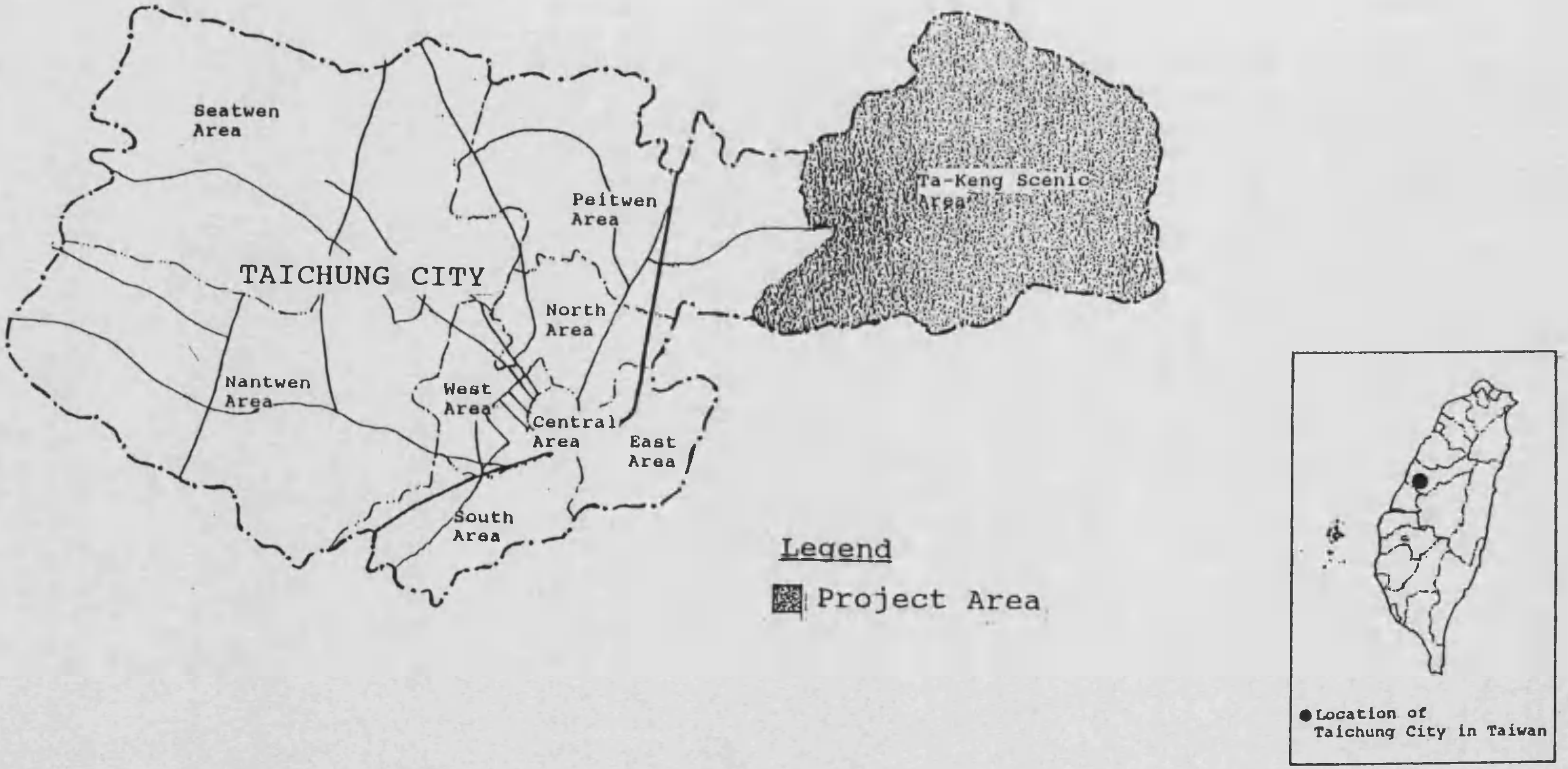


Figure 7.1 Project Area

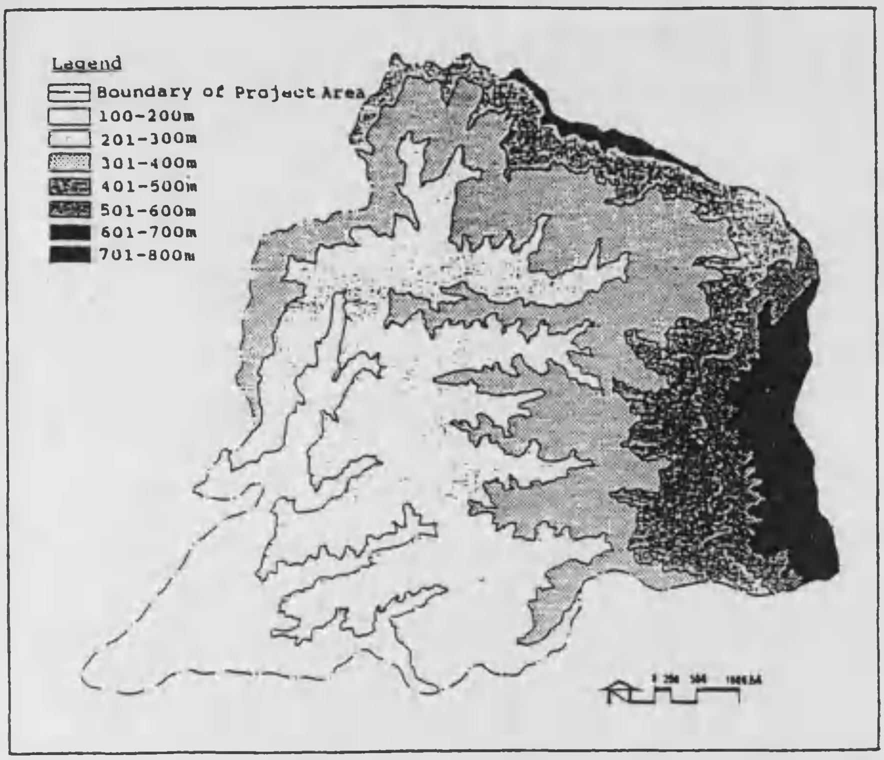


Figure 7.2 Topography

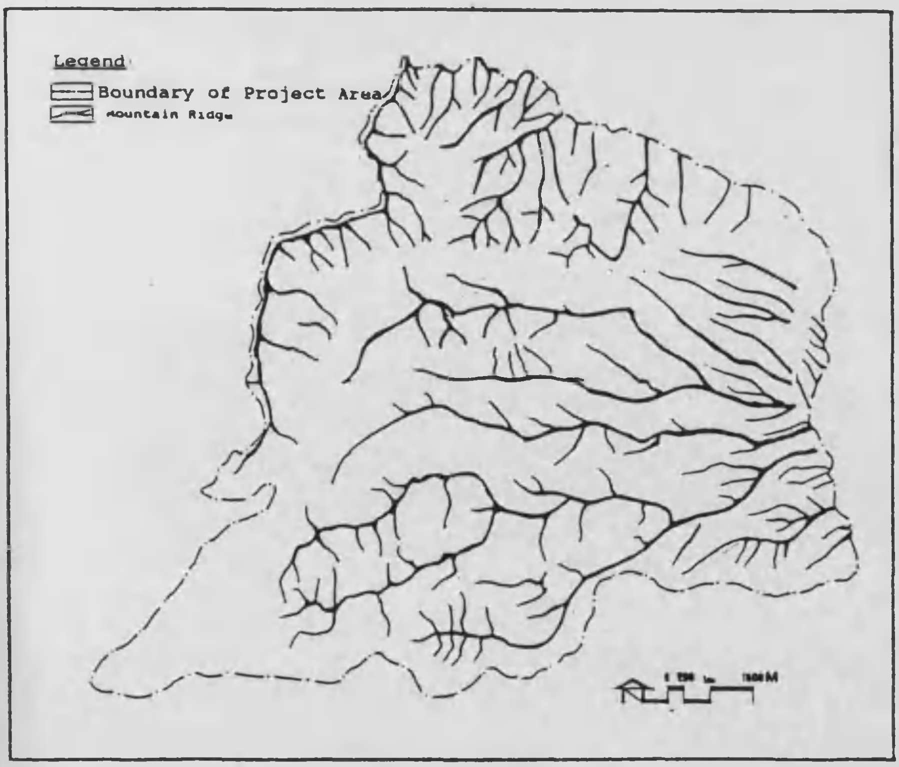


Figure 7.3 Mountain Ridge

Most of the area is mountainous with 70% above 30% in gradient. Hence the slope aspects also vary greatly. (Fig. 7.5) (Table 7.1)[1]

Table 7.1 Slope Classes and Area Extent

Slope (%)	Area (ha)	Percentage (%)	Slope (%)	Area (ha)	Percentage (%)
0-5	450	13.64	31-45	900	27.27
6-15	250	7.58	45+	1,400	42.42
16-30	300	9.09			

Source: Taichung City Government, 1988

2. Soil and Geology

Most of Ta-keng Scenic Area has soils of yellow loam, coarse in texture, with a shallow profile exhibiting many rust lines. The soil surface has many boulders and there are unconsolidated rock strata, thus water and soil retention is very low. The rock strata of the area were formed from sedimentary deposits. Among these, shale is vulnerable to weathering, erosion, and collapse; sandstone is comparatively resistant. Sandstone and shale are often found in alternating strata which affect the stability of the slopes.

3. Microclimate

During winter, the prevailing northeast winds often blow in the area. The average temperature then is about 20 ^{o}C. May to August of each year is the rainy season.

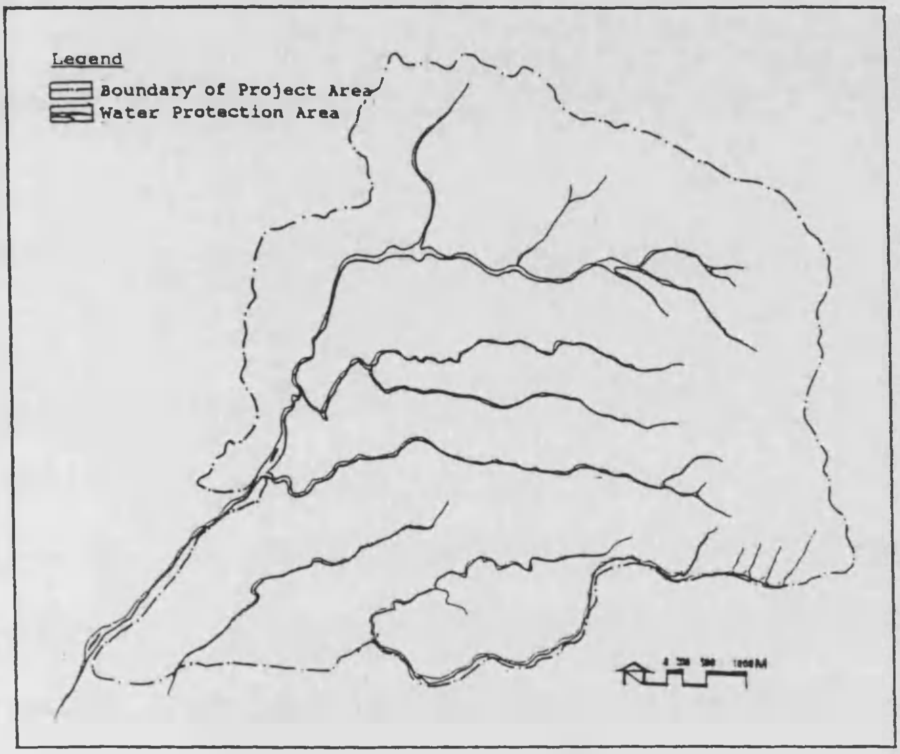


Figure 7.4 Water Protection Area

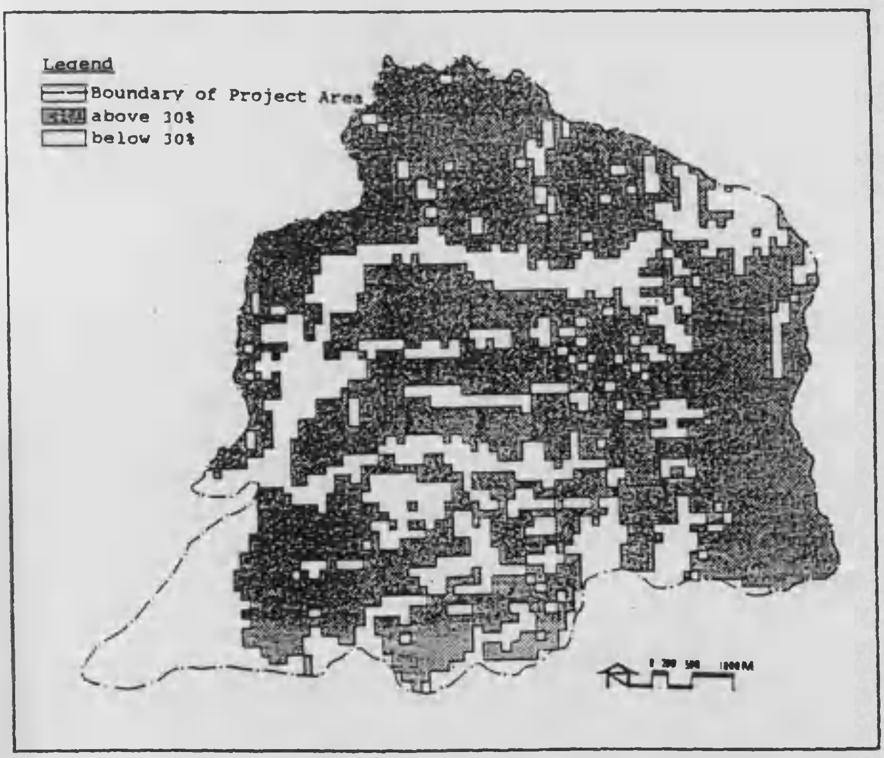


Figure 7.5 Slope

The climate is generally dry and warm in autumn, mild and rainy in spring, and humid and hot in summer.(1)

4. Plants and Animals

Plants and animals species are numerous in the area.(2) But, because of the rapidly growing influx of tourists and illegal land clearing, habitat destruction has been serious.

7.2.2 Social Environment

1. Population

The population of Ta-keng Scenic Area increased from 11,869 in 1972 to 13,685 in 1982. The population density was 3.60 persons/ha in 1972 and 4.15 persons/ha in 1982. The population of the area tends to be outflowing because of lack of job opportunities.(3)

2. Production Activity

In contrast to the economic development of Taichung city, the development of the area has been rather slow because of its location and other limiting factors. Concomitant with the development of the area in recent years, commercial and service industries have been introduced, leading to the change in economic structure.

3. Communication and Transportation

Ta-keng is located at the northeast corner of Taichung city. Owing to the rapidly increasing demand for recreational activities in recent years, the need for mass transportation is urgent. The public transportation system which passes through the area is shown in Table 7.2.[1] Communication within the area is difficult because of the terrain. (Fig. 7.6)

Table 7.2 Public Transportation System

Carrier	Route Number	Locality	Remarks
Taichung Bus System	6	Train station -- Ta-keng	1. Some buses also go to Ku-pin Hotel 2. All three routes run every 5-7 minutes
	12	Train station -- Chung-Hsing mountain range	
	15	Train station -- Put-zu-keng	
Jen-yu Bus Company	1	Lu-chuan -- Ta-keng	Every 6-10 minutes
	21	Lu-chuan -- Kuei-cheng Village	Every 10-15 minutes
	31	Lu-chuan -- Chung-Hsing mountain range	Every 1-2 hours
	32	Lu-chuan -- Pu-tzu-keng	Every 40-60 minutes
Feng-yuan Bus Company		Train station--Ta-keng Chung-Hsing mountain range--Hsinsheh	Every 10-40 minutes

Source: Taichung City Government, 1988

7.2.3 Present Situation of Land-use

The land-use of the area can be divided into two major types.[4] The first is the land used for urban development, totalling 134.48 ha and covering 4.075% of the area. The second is the non-urban development area, totalling 3165.52 ha and covering 95.925% of the area. Most of the land is privately owned, while only 647.9 ha are government owned and occupy some 20% of the area. The present land-use of Ta-keng Scenic Area is shown in Table 7.3.(1)

Table 7.3 Present Land-use of Ta-keng Scenic Area

Land-use Category		Area(ha)	Land-use Category as Percentage of Surface Area of Urban or Non-urban Area	Land-use Category as Percentage of Surface Area of Ta-keng Scenic Area
Urban Land-use	Residential	43.51	32.354	1.320
	Business	4.23	3.145	0.130
	Industrial	0.46	0.342	0.010
	School	6.78	5.042	0.210
	Social Services	4.71	3.502	0.140
	Market	0.27	0.200	0.008
	Recreation	35.52	26.413	1.076
	Hotel	1.94	1.443	0.059
	Public Institution	0.13	0.097	0.004
	Temples	3.1	2.305	0.094
	Roads	33.83	25.156	1.025
	Sub-total	134.48	100.000	4.075
Non-urban Land-use	Tombs	5.23	0.165	0.158
	Orchard & forestry	2,879.68	90.970	87.263
	Rivers	129.04	4.076	3.910
	Farm land	151.57	4.788	4.593
	Sub-total	3,165.52	100.000	95.924
	Total	3,300.00		100.000

Source: Taichung City Government, 1988

7.3 Evaluation of the Recreation Development Potential

There are about 66833 ha of land area providing different recreation resource such as stream and valley, lake and reservoir, farmland, temple and relic, etc. for recreation activities in Taiwan.(5) 21340 ha are in the northern region occupying about 32% of the total recreation area of Taiwan; 15780 ha are in the central region, occupying about 23.6% of the total area; 20550 ha are in the southern region, occupying about 30.1% of the total area; and 9163 ha are in the eastern region, occupying about 13.7% of the total area. A description of the recreation resources of Ta-keng Scenic Area and the central region of Taiwan follows. (Figs. 7.7, 7.8)

7.3.1 Recreation Resources Analysis

1. Central Region

(1) Natural Resources (6)(7)

a. Resources along The Coast

The central region is located alongside the Taiwan Strait. The length of the central coast line is about 180Km and mostly includes shallow water beaches and reclaimed land which can be used for seascape observation or fishing. Some bathing beaches, such as Kee-ting, Tung-tsiao, Ta-an and San-tiao-lun have been established. Four other sites are in a rough stage, but possess development potential.

b. Lake and Reservoir Resources

With rugged terrain and great changes in altitude, the central region is abundant in lake and reservoir resources. Most of these water bodies can be used for fishing and boating activities. In connection with the surrounding orchards and forests, it forms a attractive landscape.

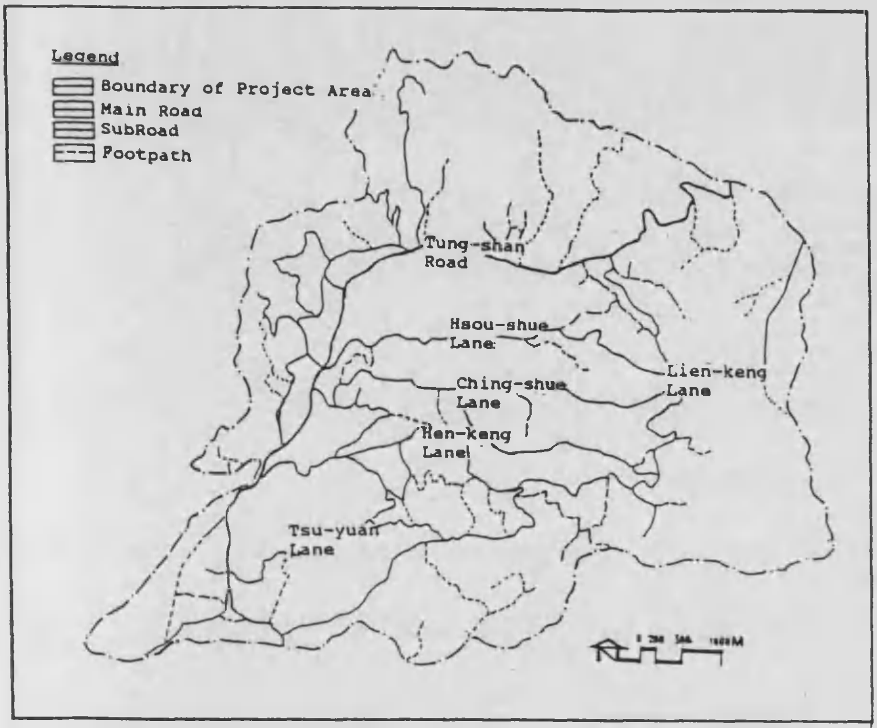


Figure 7.6 <u>Transportation System</u>

Figure 7.7 <u>Main Recreation Spots in the Central Region of Taiwan</u>

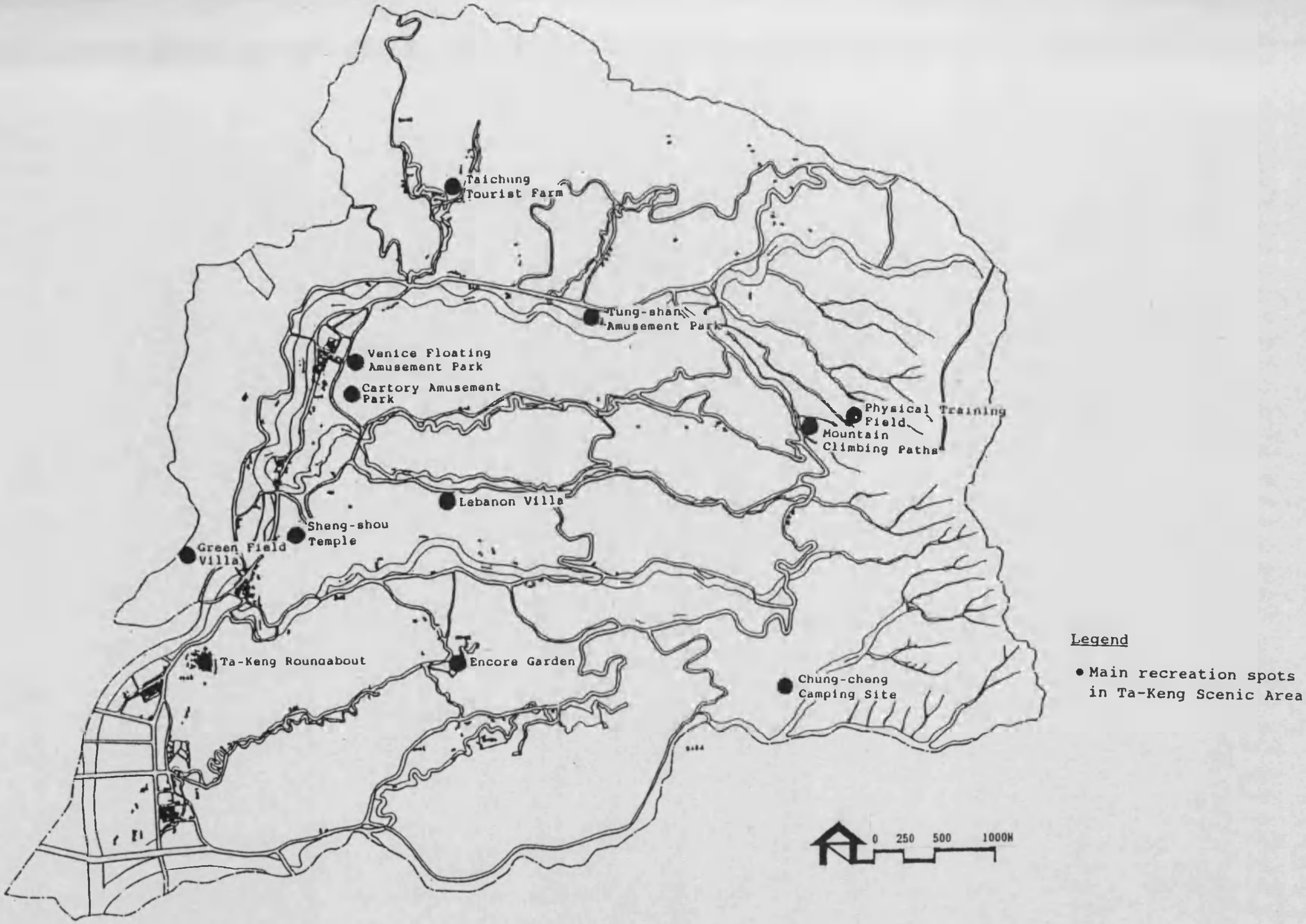


Figure 7.8 Main Recreation Spots in the Ta-Keng Scenic Area of Taichung, Taiwan

c. Stream and Valley Resources

There are six primary and three secondary streams in the central region. They all receive does large amount of fall on a yearly basis, but the amount does not spread evenly through the year. Most of the rainfall is concentrated from June to October, mostly brought by typhoons and other heavy rains. In the upper stream zone, for the dredging effect of the water, there are waterfalls, deep ponds, and eroded steep terrain.[7][8] Ku-kuan, Tai-kee canyon and Shang-lung (double dragon) waterfall are some of the most important natural resources of the region.

d. Forestry Resources

The forestry area of the central region covers 508,710 ha occupying 28.1% of the total forestry area of Taiwan or 48.49% of the area of this region. They are mostly scattered over the mountain area of Miaoli, Taichung and Nantou counties. They are broad in area, graceful in landscape, not only having recreational function but also having a nursery and protection function for wildlife. They also have the function of preventing soil erosion, regulating direct water flow and reducing flood disasters as well as improving the natural environment.

e. Mountain Resources

The terrain of the central region is very irregular with altitudes rising to peaks of 3900m. Yu-shan (Jade Mountain) is the highest on the island. Other mountains and high peaks arrange in lines. The abundant mountain resources provide favourable places for use for mountain climbing, hiking, camping and nature trails.

(2) Artificial Resources

a. Relics and Building Resources

Relics and building resources of the central region are mainly traditional cultural objects, structures or temples. Among these, the Lin residence of Wu-fung, built in the traditional style, still has a sightseeing value. Lukang (deer harbour) is a traditional cultural attraction and retains some of the municipal building types of mainland China. Chao-tien-kung (worship heaven palace) of Pei-kand (north harbour) has the most famous Ms-tsu Temple and the value of a religious relic.

b. Artificial Recreation Resources

Artificial recreation areas of the central region are few. Most of them co-exist with resources of other types. Their facilities are varied. Nevertheless, they can provide visitors with places of recreation.

2. Ta-keng Scenic Area

(1) Natural Resources (6)(7)

a. Stream and Valley Resources

As the terrain of the Ta-keng Scenic Area is generally steep, precipitation is concentrated both seasonally. In storms the soil has low water retention and the streams nearly dry up during much of the year. When heavy rains fall, floods occur rapidly. The stream lengths are short but the wide flood plains created by the "side-erosion effect" of the currents have become good places for recreation activities. (Photo 7.1)[7][8]

b. Forestry Resources

In the Ta-keng Scenic Area, the climate is generally moderate. Forests are dense and thriving. Besides the effect of soil and water retention and climate regulation. Forests can provide nature sightseeing and the study of ecology. (Photo 7.2)

c. Mountain Resources

The terrain of Ta-keng Scenic Area rises gradually from west to east, from 112m above sea level to 858m. Tou-ko mountain on the east side is the highest. At the present time, the linking path from Tou-ko mountain to Er-tou-ko mountain and five other branch mountain climbing paths have been completed and opened. They can provide hiking, mountain climbing, nature sightseeing and other kinds of activities. In the future, this area can be developed along with the existing trail system to facilitate an adequate arrangement of facilities and to strengthen their convenience and variability of use. (Photo 7.3)

(2) Artifical Resources

a. Ta-keng Roundabout

Ta-keng Roundabout does not have any recreational value. It is the entrance point for visitors and is the landmark of Ta-keng Scenic Area. (Photo 7.4)

b. Sheng-shou Temple

The temple offers religious activity as a recreation resource. (Photo 7.5)

c. Lebanon Villa and Green Field Villa

Both of these villas use mountains and villages as their main recreation resources and provide lodging for visitors so that they can have more time and chance for visiting Ta-keng Scenic Area. (Photo 7.6)

d. Cartory Amusement Park

Taking advantage of slope variation, there are five zones cultivated in the park. From zone 1 to zone 4 are the amusement installation areas. The fifth zone has a zoo. The park is mainly a manmade amusement park. (Photos 7.7,7.8)

e. Venice Floating Amusement Park

This is a spot mainly for water surface recreation activities. It has 22 kinds of facilities. Within the park, there are snack bars, cold drink stands, and an open picnic and barbecue field. The management is competent. (Photo 7.9)

f. Taichung Tourism Farm

The farm mainly grows fruits during all four seasons. It is an open-type management farm. Additionally, there are barbecue and camping sites, vacation villas and tea ceremony houses. (Photo 7.10)

g. Tung-shan (east mountain) Amusement Park

This is a recreation spot completed in early 1989. It is somewhat like the Cartory Amusement Park in its natural setting but also an artificially established recreational area. (Photo 7.11)

h. Physical Training Field

This mainly serves teenagers for physical training. Various kinds of training facilities and equipment are provided. (Photo. 7.12)

i. Mountain Climbing Footpaths

Five footpaths have been established, measuring 2870.5m. Besides small footpaths, there are terrace seating areas. After the completion of the mountain climbing footpaths in 1980, it has become the best place for mountain climbing and hiking in Taichung district. (photo 7.13)

j. Chungcheng Camping Site

This is a recreation spot mainly for its mountain and valley resources. It is used for camping and barbecue. (photo 7.14)

k. Encore Garden

This is a recreation spot mainly for its mountain and stream valley resources. It is also a garden offering enjoyment of the vegetation and plant study. The garden receives the largest number of visitors in Ta-keng Scenic Area since it opened to the public in 1983. (photos 7.15,7.16) The recreation resource analysis of the recreation spots mentioned above are listed in Table 7.4.

7.3.2 Potentiality Analysis of Recreation Development

The potentiality analysis of recreation development of this study is in reference to "Taichung City Tourism

Photo 7.1 Stream and valley

Photo 7.2 Forestry

Photo 7.3 Mountain

Photo 7.4 Ta-keng Roundabout

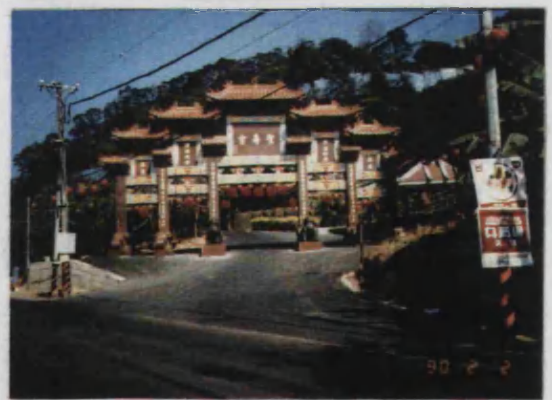


Photo 7.5 Sheng-shou Temple

Photo 7.6 The villas

Photo 7.7 Cartory Amusement Park

Photo 7.8 Cartory Amusement Park


Photo 7.9 Venice Floating Park


Photo 7.10 Taichung Tourism Farm


Photo 7.11 Tung-shan Park


Photo 7.12 Physical Training Field


Photo 7.13 Climbing Footpath


Photo 7.14 Chungcheng Camping Site


Photo 7.15 Encore Garden


Photo 7.16 Encore Garden

Table 7.4. Recreation Resources Available at Ta-keng Recreation Spots

Recreation Resource characteristics	Name of Recreation spots	Ta-keng Roundabout	Shemg-Shou Temple	Lebanon Villa	Greenfield Villa	Cartory Amusement Park	Venice Floating Amusement Park	Taichung Tourist Farm	Tungshan Amusement Park	Ta-keng Physical Training Field	Ta-keng Mountain Climbing Footpath	ChungCheng Camping Site	Encore Garden
Resource Type	Mountain		●	●	●		●	●	●	●	●	●	●
	Lake, Dam												
	Stream, Valley												
	Park, Amusement Field			●	●	●	●		●				●
	Special Artificial Facilities	●							●	●			●
	Relics, Buildings												
	Temples, Ancestral Temples		●										
	Special Geology & Topography		●										
	Special Animals & Plants												
	Production Visit							●					●
	Farmscape							●					
Use-Season	Spring		●	●	●	●		●	●	●	●	●	●
	Summer		●	●	●	●	●	●	●	●	●	●	●
	Fall		●	●	●	●	●	●	●	●	●	●	●
	Winter		●	●	●	●		●	●	●	●		●
Time Needed for Round Trip	Within two hours		●		●					●		●	
	Within four hours			●		●	●	●			●		
	Within one day												●
	> day											●	
Time	Daytime	●	●	●	●	●	●	●	●	●	●	●	●
	Nightime	●	●									●	●
	Other time												
Area	< 1 ha	●											
	1-5 ha		●		●	●	●			●			
	5-10 ha			●								●	
	10-50 ha							●					●
	50-100 ha												
	> 100 ha												
	others												
Consumption Trends	High					●			●				●
	Medium							●					
	Low		●	●	●		●			●	●	●	

Development Comprehensive Plan".[9] The study cites the evaluation method of the specified scenic areas by the Tourism Bureau, Ministry of Communications. The purposes of the evaluation are to set up a development function for all recreation areas, to guide the construction of recreational and service establishments and to direct investments for the highest benefits. The evaluation structure is shown in Table 7.5.[10] The study classifies the recreation spots of Taichung into four classes according to their development potential. Definition of the classes is as follows:[11]

Class A: Site resources have unique characteristics, a large area size and can provide a large variety of recreation enjoyment. Additionally, the site has adequate development space and can be developed into a provincial recreation area.

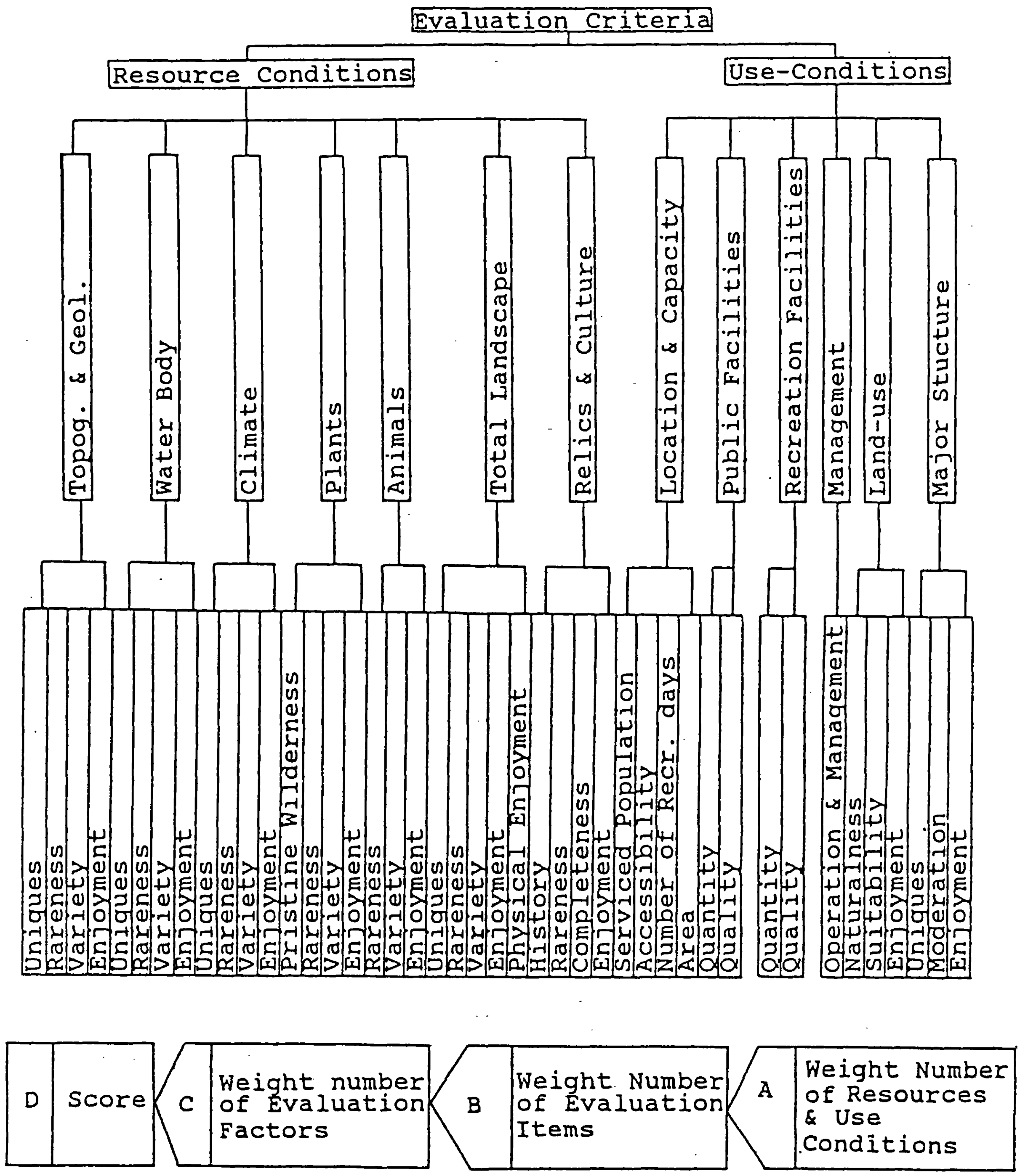
Class B: The area size and resource characteristics are of a lower rank to these of Class A. But the site has adequate development space and can be developed into a regional recreation area.

Class C: The site has special scenery and adequate area size and can be developed into a recreation area.

Class D: The area size and resources characteristics are of lower rank to those of Class C. They belong to local recreation areas.

Different weighted indices are given to the evaluation

Table 7.5. Evaluation Diagramme of Development Potential of Taichung Recreation Areas



Note: Development Potential Evaluation Formula for Recreation Areas: $\Sigma Ai \times Bi \times Ci \times Di$ (Source: Feng Chia University, 1988) items and evaluation factors according to their characteristics. Ten evaluation elements are grouped into the mountain-stream-valley type and artificial facilities type to act as the evaluation weight basis. The evaluation weighted indices are shown in Table 7.6.[12]

It is obvious from the evaluation results that the present recreation spots of Ta-keng Scenec Area belong mostly to class C or D, that is, the county or local recreation classes. As a matter of fact, the development of Ta-keng Scenic Area has significant value to the people of a city like Taichung, which has a population of 760,000. Furthermore, the management style of Encore Garden within the area shows that Ta-keng Scenic Area has some provincewide recreation value.

7.3.3 Suitability Analysis of Recreation Activities

The purpose of analysing the activity suitability of a recreation area is to find out the relationship between recreational activities and resources and the relationship between every kind of recreation. The analysis is used as the basis for recreation activity planning and to maintain recreation quality. Recreation activities generally can be classified, according to their resources from which the activity difference is formed, into land-based and water-based recreation activities. Details are listed in Table 7.7.

Table 7.6 Development Potential Evaluation Weighted Indices of Taichung Recreation Spots

Items		Weighted Indices							Total
		Resource Conditions 55				Use-Conditions 45			100%
Resource conditions	.Mountain stream Valley	Resource Conditions: Geo & Topog 21	Water Body 13	Meteorol 9	Plants 19	Animals 10	Total Land-scape 17	Relics & Culture 11	100%
Resource conditions	.Artificial establishment	Resource Conditions: Geo & Topog 14	Water Body 14	Meteorol 9	Plants 15	Animals 8	Total Land-scape 20	Relics & Culture 20	100%
Use condi-tions		Use-Conditions: Location & Capacity	Public Facili-ties	Recreation Facili-ties	Management	Land Use	Major Struc-tures		100%

Resource evaluation factors	Factor	Weight
Geo & Topog	Uniques	29
	Rareness	23
	Variety	21
	Enjoyment	27
Water Body	Uniques	25
	Rareness	20
	Variety	25
	Enjoyment	9
Meteorol	Uniques	24
	Rareness	20
	Varieay	25
	Enjoyment	31
Plants	Primitiveness	72
	Rareness	24
	Variety	24
	Enjoyment	30
Animals	Rareness	35
	Variety	28
	Enjoyment	37
Total Land-scape	Uniques	19
	Rareness	20
	Variety	18
	Enjoyment	21
	Physical Enjoying	22
Relics & Culture	History	30
	Rareness	24
	Completeness	23
	Enjoyment	23
General Evaluation of every item:		100%

Use condition evaluation factors	Factor	Weight
Location & Capacity	Serviced Population	28
	Accessibility	34
	Number of days for recreation	18
	Land Area	20
Public Facili-ties	Quantity	46
	Quality	54
Recreation Facilities	Quantity	42
	Quality	58
Manage-ment	Management	100
Land Use	Naturalness	30
	Suitability	30
	Enjoyment	32
Major Struc-tures	Uniques	29
	Moderation	36
	Enjoyment	35
General evaluation value of every item:		100

Source: Feng Chia University, 1988

Table 7.7 Recreation Activity Classification

Activity classification	Activity
Land-based recreation activities	mountain climbing, hiking, bicycling, nature sightseeing, natural specimen collection, children's plays, shopping, physical training, golf, visiting temples, natural landscape enjoyment, observing wildlife, looking at artificial scenery, horse riding, enjoying forklore activities, parachuting, grass skiing.
Water-based recreation activities	swimming, fishing, rowboating, sailboating, water playing, water skiing.

In finding out the suitable recreation activities of a recreation area, four themes must be analysed:

(1) Relevance analysis between recreational activities and resources

(2) Dynamic and static analysis of recreation activities

(3) Activities to wilderness-demand analysis

(4) Functional relevance analysis of recreation activities

1. Relevance analysis between recreational activities and resources

Different recreation activities in relation to the environmental condition demands have different requirements. Some activities have to proceed under the requirement of maintaining the wilderness of the natural resources. Some must be supported by artificial facilities to provide recreational opportunities. Others lie between the two. From the relevance analysis of the recreation activities and resources, it is known which kind of recreation resource will be suitable to what kind of recreation activity. From the matrix analysis (Table 7.8)[13], we know the relevance of the recreation activities to the recreation resources.

2. Dynamic and Static Analysis of Recreation Activities

From the physical and mental enjoyment of tourists the dynamic and static tendency of the activities can be estimated. (Table 7.9)[14]

3. Recreation Activities to Wilderness-demand Analysis

Recreation activities are different in nature, some tend to be held in the urban area, others in the primitive areas. (Table 7.10)[15]

4. Functional Relevance Analysis of Recreation Activities

The relevance indicates the recipient or conflict functional relationship of recreation activities. Hence it is known what activities can proceed at the same time and place without lowering recreational quality. The relevance of the recreation activities are detailed in Table 7.11.

From the above analysis and in consideration of the effect upon the landscape and ecological environment made by the recreation activities, the recreation

Table 7.8 Relevance Matrix of Recreation Activities with Recreation Resources

Classification of Recreation Activities	Classification of Recreation Resources	Mountain	Lakes & Dams	Streams & Shrubs	Grassland & Valleys	Special Geol & Topog Landscape	Special species of Animals & plants	Relics & Buildings	Temples & Ancestral Temples	Special Artificial Establishment	Folklore Activities & Arts	Production Visit	Farmscape
Land-based Recreation Activities	Mountain Climbing	●	○	○	●	○	○						○
	Hiking	○	○	○	○	○	○	○				○	○
	Camping	○	○	●	○								○
	Picnicking & Barbeçuing	○	○	●	○							○	○
	Driving	○	○	○	○			○	○	○		○	○
	Bicycling		○							○		○	●
	Nature Trailing	●	○	●		○	○						
	Production Visit											●	
	Natural Specimen Collecting	○	○	○	○	●	●						○
	Children's Plays			○	○					●			
	Shopping									●		○	
	Physical Training	○		○	○					●			○
	Golf				●					●			
	Horse Riding				●					○			○
	Parachute Jumping				○					●			
	Grass Skiing				●								
	Festival Celebration							●	●	●	●		
	Nature Sightseeing	●	●	●	●	●	●						
	Forklore Activities							○	●	○	●		
	Wildlife Observation	○	○	○	○	○	●						
	Watching Artificial Scenery							●	○	●			
	Temple Visiting							○	●				
Water-based Recreation Activities	Swimming		●	●									
	Stream Fishing			●	○								
	Lake Fishing		●	○									
	Rowboating		●	●									
	Sailboating		●	○									
	Water Skiing		●	○									
	Water Playing		●	●						●			

● Indicates: Sufficient and must exist
○ Indicates: Sufficient but not must exist

Table 7.9 Dynamic/Static Trend Scale of Recreation Activities

		Static -5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5 Dynamic
Water-based Recreation Activities	Mountain Climbing	**************
	Hiking	**********
	Camping	****************
	Picnicking & Barbecuing	*************
	Driving	*************
	Bicycling	*************
	Nature Trailing	*************
	Production Visit	**********
	Nature Specimen Collecting	*************
	Children's Plays	**************
	Shopping	*************
	Physical Training	***********
	Golf	*******
	Horse Riding	***********
	Parachate Jumping	***********
	Grass Skiing	***********
	Festival Celebration	**********
	Nature Sightseeing	********
	Forklore Activities	*************
	Wildlife Observation	*************
	Watching Artificial Scenery	*************
	Temple Visiting	*************
Water-based Recreation Activities	Swimming	***********
	Stream Fishing	*************
	Lake Fishing	*************
	Rowboating	**************
	Sailboating	**************
	Water Skiing	***********
	Water Playing	*************

Table 7.10 Urbanisation/Prairisation Trend Scale of Recreation Activities

		Pristine Area -5	Similar to National Park Area -4	-3	Forestry Area -2	-1	Countryside Area 0	Village Area +1	+2	Urban Area +3	+4	Urbanised Area +5
Land-based Recreation Activities	Mountain Climbing	*	*	*	*	*						
	Hiking		*	*	*	*	*	*	*	*		
	Camping		*	*	*	*						
	Picnicking & Barbecuing			*	*	*	*	*	*			
	Driving						*	*	*	*	*	*
	Bicycling						*	*	*	*	*	
	Nature Trailing	*	*	*	*	*	*					
	Production Visiting						*	*	*	*		
	Natural Specimen Collecting	*	*	*	*	*	*					
	Children's Plays								*	*	*	*
	Shopping										*	*
	Physical Training				*	*	*	*	*	*		
	Golf							*	*	*	*	
	Horse Riding						*	*	*	*		
	Parachute Jumping							*	*	*		
	Grass Skiing						*	*	*	*	*	
	Festival Celebration								*	*	*	
	Nature Sightseeing	*	*	*	*	*	*	*	*			
	Forklore Activities							*	*	*		
	Wildlife Observation	*	*	*	*	*						
	Watching Artificial Scenery							*	*	*	*	*
	Temple Visiting						*	*	*	*	*	*
Water-based Recreation Activities	Swimming							*	*	*	*	
	Stream Fishing			*	*	*	*	*				
	Lake Fishing			*	*	*	*	*	*	*		
	Rowboating				*	*	*	*	*	*	*	*
	Sailboating				*	*	*	*	*			
	Water Skiing					*	*	*	*	*		
	Water Playing					*	*	*	*	*	*	*

Table 7.11 Functional Relevance Matrix of the Recreation Activities

		Land-based Recreation Activities																						Water-based Recreation Activities						
		Mountain Climbing	Hiking	Camping	Picnicking & Barbecuing	Driving	Bicycling	Nature Trailing	Production Visting	Nature Specimen Collecting	Children's Plays	Shopping	Physical Training	Golf	Horse Riding	Parachute Jumping	Grass Skiing	Festival Celebration	Nature Sightseeing	Folklore Acty	Wildlife Observation	Watching Artificial Scenery	Temple Visiting	Swimming	Stream Fishing	Lake Fishing	Rowboating	Sailboating	Water Skiing	Water Playing
Land-based Recreation Activities	Mountain Climbing																													
	Hiking	o																												
	Camping	o	o																											
	Picnicking & Barbecuing	o	o	o																										
	Driving	×	×	-	-																									
	Bicycling	×	×	×	o	-																								
	Nature Trailing	o	o	o	o	-	-																							
	Production Visiting	-	-	-	o	o	o	-																						
	Natural Specimen Collecting	o	o	o	o	×	-	o	-																					
	Children's Plays	-	-	-	o	×	×	-	o	-																				
	Shopping	-	-	-	-	o	-	-	o	-	-																			
	Physical Training	o	o	o	o	-	o	×	o	-	o	-																		
	Golf	-	-	-	-	-	-	-	-	-	-	-	-																	
	Horse Riding	-	-	o	-		-	-	-	-	-	-	o	-																
	Parachute Jumping	-	-	o	-	-	-	-	-	-	-	-	o	×	×															
	Grass Skiing	-	-	o	o	-	-	-	-	-	o	-	o	o	×	×														
	Festival Celebration	-	-	-	-	-	-	-	o	-	-	o	-	-	-	-	-													
	Nature Sightseeing	o	o	o	o	o	o	o	o	o	-	-	o	-	o	-	-	-												
	Forklore Activities	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-											
	Wildlife Observation	o	o	o	×	×	×	o	-	o	-	o	-	-	-	-	-	-	o	-										
	Watching Artificial Scenery	-	o	-	-	o	o	-	o	-	-	o	-	-	-	-	-	o	-	o	-									
	Temple Visiting	o	o	-	-	o	o	-	-	-	-	o	-	-	-	-	-	o	-	o	-	o								
Water-based Recreation Activities	Swimming																													
	Stream Fishing																							×						
	Lake Fishing																							×	-					
	Rowboating																							×	×	×				
	Sailboating																							×	×	×	o			
	Water Skiing																							×	×	×	o	o		
	Water Playing																							o	×	×	×	×	×	

o Indicates: Having reciprocal recipient relation
- Indicates: No relation with each other
× Indicates: Having conflict relation

characteristics and the suitable recreation activities of Ta-keng Scenic Area are listed in Table 7.12.

Table 7.12 Suitability Analysis of Recreation Activities of Ta-keng Scenic Spots

Resources Charateristics			Hiking	Mountain Climbing	Physical Training	Camping	Landscape Observation	Temple Visiting	Nature Trailing	Picnicking & Barbecuing	Swimming, Water playing	Fishing, Rowboating	Bicycling	Driving	Horse Riding	Fruit Picking	Lodging	Grass Skiing	Production Visiting	Children's Plays	Forklore Activity	Wildlife Observation
Natural Resources	Topo-graphy	Flat land				●	●	●		●			●	●	●	●	●		●	●	●	●
		Hilly Land	●		●	●	●	●	●	●				●		●		●		●		●
		Steep Land					●											●				●
		Water Surface					●				●	●										
	Cli-mate	Some effect		●		●					●		●		●	●			●	●		
		A little effect			●					●		●						●			●	
		No effect	●				●	●	●					●			●					●
	Areas	< 1 ha					●	●												●		
		1-10 ha			●	●	●	●	●	●	●	●			●	●	●	●	●		●	
		> 10 ha	●	●			●	●					●	●								●
	Plant-ation	Mixed Forest Conservation	●	●	●	●	●		●	●							●					●
		Forest	●	●																		
Artificial Resources		Settlement					●															
		Temples					●													●	●	
		Villa															●					
		Amusement Park					●			●										●		
		Floating Park									●	●								●		
		Farm														●			●			
		Orchards					●									●						
		Rice Field																	●			
		Bamboo Grove					●															
		Ornamental Plants					●															
		Driveway											●	●								
		Footpath	●	●				●														
Type of Activ-ities		Purpose Type			●					●	●	●				●		●	●	●	●	
		Floating Type	●	●				●	●				●	●	●							●
		Staying Type				●	●										●					

In summary, the recreation activities suitable for Ta-keng Scenic Area are landscape observation, mountain climbing, hiking, camping, picnicking, barbecuing, nature trailing, production visiting chidren's plays, physical training, festival celebration, folklore activities, wildlife observation, temple visiting, playing in water and swimming, rowboating, etc.

7.4 Recreation Development Prediction

The recreation development of Ta-keng Scenic Area can be predicted two ways: the recreational characteristics and the number of the tourist person-visits.

7.4.1 Recreation Development Characteristics

Owing to government open policy and the higher importance given to tourism by the population, recreational demand has increased greatly in recent years. According to past changes in recreation characteristics and the social economic predicted structure changes in the future, the recreation development characteristics of the area are as follows:

1. Due to rising personal income and easier transportation, the amount of leisure time and distance people are willing to travel are lengthening accordingly. However, as the recreation system has not yet been fully established, one-day round trip excursions are still the principal recreation outing.

2. Sundays, holidays, and national holidays are the principal leisure times. Thus those days will still be the principal travelling days in the near future. Nevertheless, in coming years, the promotion of a flexible holiday system will be helpful to the dispersal of recreation time and days.

3. Family and other group excursions will still be paramount. Group recreation sponsored by business enterprises for the benefit and welfare of employees will increase.

4. Owing to the increasing rate of private car ownership, tourists who use their own cars as transportation will likewise increase. Meanwhile the mass transportation system will decrease gradually because of higher time-costs. But tourist mini-buses will become fashionable in different types of recreation.

5. On account of the continuous uplift of educational standards, demands will increase for higher quality recreational facilities. There will be more interest in informative and educational activities.

6. As the population is showing more interest in both the local and conventional culture, it is possible that future recreation activities will tend to be more localised and centred on folklore.

7.4.2 Recreation Demand Prediction

As Ta-keng Scenic Area is a regional one, the prediction of recreational demand used in this study is based on the evaluation made upon the source materials available in Taiwan and the central region in particular.

Predictions indicate that the number of person-visits in Taiwan and the central region of Taiwan will total to 116,422,000 and 25,659,000 respectively by the year 2001.[16]

There are many factors which affect the degree of recreation demand.[17] In predicting demand, often only the important ones can be considered, due to limited data. This study uses the compound regression analysis method in the general mathematical model.[18] It is assumed that amount of tourist person-visits (Y) of a certain scenic spot is affected by three factors: (1) the average number of person-visits undertaken on the island for each person per year (D); (2) the total population of Taiwan (N); and (3) the ratio of the tourist person-visits of the area to the tourist person-visits of all of Taiwan (R). The equation is

$$Y = N \cdot D \cdot R \quad \text{............} (1)$$

Ta-keng district remains a recreation area without the benefit of systematically planned development. The only spot which keeps visitor records is Encore Garden. Thus the conditions for prediction are difficult.

To find the yearly person-visits of Ta-keng Scenic Area, the above equation (1) is changed into

$$Y = N \cdot D \cdot R1 \cdot R2 \ldots\ldots\ldots\ldots\ldots (2)$$

Where: Y = yearly tourist person-visits of Ta-keng Scenic Area;

N = total population of Taiwan;

R1= ratio of tourist person-visits of the central region to the person-visits of all of Taiwan;

R2= ratio of the Encore Garden to tourist person-visits to the tourist person-visits of the central region;

D = average frequency of tourist person-visits in Taiwan per person per year.

Data show[16] that the tourist person-visits in the central region amounts to 22.04% of the person-visits of Taiwan (R1). However, in equation (2), the ratio (R2) was taken from Encore Garden, where from 1984 to 1988 the mean value of the person-visits ratio of Encore to that those of the whole central region was 8%. When values N, D, R1, R2, are placed into equation (2), then the person-visits which may be attracted by Ta-keng Scenic Area in the year 2001 will reach 10,058,828 person-visits (Table 7.13).

7.5 Related Plans and Regulations

7.5.1 Compulsory Plans

1. Comprehensive Development Plan of Taiwan[19]

    (1) Planning Goals

Table 7.13 Predication of Person-visit of Ta-keng Scenic Area

Person visits / Year	(1) Average person-visit per person per year	(2) Total population of Taiwan	(3) Person-visit in central region of Taiwan	(4) Person-visits in Ta-keng Scenic Area
1991	3.1718	21,000,000	14,680,000	3,730,037
1996	3.9585	22,356,000	19,505,000	6,159,337
2001	4.9123	23,700,000	25,659,000	10,058,818

Source: (1):[16,18], (2):[19], (3):[17], (4):prediction made by this study

a. Achieve reasonable spatial distribution of population and economic activities.

b. Improve living and working environments.

c. Conserve and develope natural resources.

(2) Development Plan for Recreation Resources

a. Take care of international tourism and domestic recreation demand concurrently.

b. Pay attention to recreation resources development and conservation.

c. Match recreation resources development with recreation patterns.

d. Strengthen transportation facilities between recreation sites.

e. Construct special tourist recreation facilities with relate to urban systems.

f. Strengthen public facilities in recreation areas.

2. The Central Regional Plan [20]

(1) Development Goals

a. Promote economic development and create employment opportunities, in order to raise living standards and decrease population outflow.

b. Spatially distribute population and production activities to promote urban and rural development in parallel.

c. Set up urban systems of recreation and provide urban areas of all levels with public facilities that would improve urban functions and reduce quality of life differentials between citizens.

d. Promote integration of recreation facilities with related constructions.

e. Provide rapid, economical, safe transportation systems corresponding to the demands of passengers and goods.

f. Control all land-use and improve environmental quality.

g. Explore and conserve water, land, mineral, forest, and recreation resources.

(2) Development and Conservation of Recreation Resources

a. Conservation of natural recources must take priority over their economic development unless conservation and development can proceed hand in hand with no, or little, adverse affects on the former.

b. Development of recreation resources should coincide with changes in recreation patterns and quantitative demand.

c. Areas rich in recreation resources should be planned first and developed later and set up with a management system.

d. Along with the development of recreation resources, the transportation network between recreation areas should be emphasised.

e. Both international and domestic recreation demands should be addressed concurrently.

f. Development of recreation resources should mesh with other economic and social infrastructure and development in order to enhance the whole national development.

g. Construction of special recreational facilities should be related to the urban system.

h. The natural landscape along roadsides should be strictly managed and maintained.

7.5.2 Related Plans

1. The First Overall Review Booklet in Changing the Master Plan of the Expanded Taichung City Urban Plan (Ta-keng Scenic Area)

(1) Reasons for the "Overall Review"

The detailed plan of Ta-keng Scenic Area of

Taichung city was publicly displayed in August, 1980. Through the decision of the 107th meeting of the Taichung City Urban-Planning Committee, an overall review of the land-use of the scenic area was promulgated. The master plan of Ta-keng Scenic Area was used as the basis of the overall review. The master plan has been passed in 1976 for implementation.

(2) Anticipated Goals

a. Construct Ta-keng Scenic Area as a local recreation area, according to the guidance of The Central Regional Plan.

b. Conserve and use local natural resources reasonably and provide citizens with residential, leisure, and recreational spaces.

c. Review the current developments infrastructure and situation and demand of the area and modify to suitable land-uses.

d. Modify and correct the original detailed plan and effectively develop the resources of the area to further promote tourism.

e. Hold public opinion in greater account and accept reasonable suggestions brought up by organisations and citizens to reduce difficulties in the implementation of the urban plan.

f. Produce a complete set of charts illustrating the urban plan to facilitate the execution of the plan and promote public understanding.

(3) Planning Principles

a. Maintain the natural landscape and the local characteristics.

b. Take care of the present situation and future development concurrently.

c. Make the best use of government-owned and large privately owned lands to install public facilities.

d. Maintain the original special sights and relics.

e. Replace the abandoned Ta-keng reservoir with a dam and lake for tourist use.

f. Designate the land prone to slides or collapse as protected areas, in order to restrict its development.

g. Control ground modelling and provide water and soil retention, in order to maintain the landscape and safety.

h. Review the transportation system of the original detailed plan and construction zoning controls.

(4) Planned Year Period: 2001 A.D.

2. Comprehensive Transportation Planning Report of Taichung Metropolitan Area.(22)

(1) Planning Goals

a. Ascertain traffic bottlenecks and other defects of the existing transportation system and work out an improved plan in a short period of time.

b. Analyse mid-term and long-term social and economic development and land-use changes in the central region of Taiwan to find out the growth in, and types of, future transportation demand.

c. Set the development policy of mid-term and long-term transportation systems, including road construction and the public transportation network.

(2) Recreation and Tourist Roads Improvement Plan

a. Construct Tai-yuan road and extend it to Ta-keng Scenic Area to share the carrying capacity of Tung-shan road.

b. Broaden county road No. 129

i. from Taiping Hsiang to Ta-keng along county road No. 136 turning on to county road No. 129;

ii. from Tali Hsiang directly to Ta-keng along county road No. 129;

iii. Visitors travelling from the direction of Nan-tou, Chunghsing New Village, and Tzao-tun can turn on to this county road to Ta-keng.

3. Other Related Plans

(1) Ta-keng Tourist Farm Village Planning Study.

(2) Residential Community Area Development Model Study of Ta-keng Hillside Area.

(3) Physical Planning of Encore Garden.

(4) Ta-keng Tourism Dam Plan.

(5) Woods Park Plan.

(6) Ta-keng Forestry Recreation Area Management Plan.

(7) New Subcentre Plan of Taichung.

7.5.3 Related Acts and Codes

Because the Ta-keng Scenic Area is situated on a steeply sloping mountaineous area, the related acts and codes relevant for the planning of the area include the management items of both the Hillside Area and the Recreation Area Development Control Acts. (Table 7.14)[2]

7.6 Development Feasibility Analysis

7.6.1 Matching Conditions to Regional Development

Ta-keng Scenic Area is located in the suburban area of Taichung city. It has highly enjoyable scenery which makes it one of the famous scenic areas in the central region of Taiwan. In recent years, due to the rapid growth of Taichung city, the total population has been increasing rapidly. Along with economic development and uplift of living standards, leisure time activities are given high priority by the population. However, leisure time space is not sufficient and urban environmental quality is becoming worse day after day. In recent years, all over the Ta-keng area newly established amusement places, villas, and high-class residences can be seen. If they can be linked with transportation connections to make integrated development, then Ta-keng, among all the recreation districts of central Taiwan, with its communication conveniences and natural landscape resources would possess the most development potential.

7.6.2 Recreational Opportunities Analysis

Table 7.14 Present Hillside Area and Recreation Area Development Control Acts

	Acts and Codes	References
Development Plan	Urban Planning Acts, Articles 24,30,40	Urban Planning statutes by Bureau of Construction of the Ministry of Interior. May, 1984. page 7-10
	Forestry Recreation District Acts of Taiwan Province, Art. 2	Collection of Related Acts of Tourism, by Bureau of Tourism of the Ministry of Communications. June, 1987. Page 421
Water-Soil Retention	Hillside Area Protection and Use Acts, Art. 6, 10, 13, 30	Ibid. Pages 390-395
	Implementation Details of Hillside Area Protection and Use Acts Art. 5, 6, 12, 17	Ibid. Pages 400-403
	Hydraulic Acts Art. 72, 78	
	River Management & Planning of Taiwan Province Art. 20	
Land-use	Implementation Details of the Municipal Planning in Taiwan Province Art. 24, 25, 26	Municipal Planning Acts, by Bureau of Construction of Ministry of Interior. May, 1984. Pages 36, 37
	Forestry Acts, Art. 30, 34	Collection of Related Acts of Tourism, by Bureau of Tourism of the Ministry of Communications. June,
	Tourism Development Regulation, Art. 13	1987. Pages 382-383 Ibid. Page 4
	Temporary Recreation and Camping Facilities Setting up Points in the Protection Destrict of Taiwan Urban Planning, Art. 5	Ibid. Page 127
Building Design	Tourism Development Regulations, Art. 11	Ibid. Page 3
	Planning Restrictions Implementation Regulations of Buildings, Advertising Objects, Stands in Recreation Area	Ibid. Pages 127-130
	Building Codes of Taiwan Province	
	Construction Technique Planning and Construction Design Implementation Section	

The recreational opportunities of Ta-keng Scenic Area can be classified according to Clark and Stankey's (1979) suggested Recreation Opportunity Spectrum (ROS), into several fields for discussion:

1. Recreation Area Accessibility

(1) Accessibility from Outside the Area

From Table 7.2, it is clear that the public transportation system available in Ta-keng Scenic Area is fairly complete. In the future, if the area is fully developed, the present carrying capacity would not be able to meet projected needs.

(2) Accessibility Inside the Area

Inside the area there are hill traversing roads running through. With the secondary roads as well as farm roads, it is possible to reach anywhere inside the area. The area is thus sufficient in accessibility.

2. Nonrecreational Resources

The nonrecreational resources of the area include farmland, forestry and orchards.*

3. Management

According to planning goal and related regulations, the purpose of management is to promote economic

* A draft act of "The Policy for the Development of Leisure Agriculture" is past on to Parliment for discussion after the study is completed.

development of the local area with attention paied simultaneously to natural ecological protection. Therefore, recreation activities and facilities should not damage natural resources as a basic consideration. In the arrangement of recreation facilities, besides consideration being given to ecological protection, visitor draw-in and recreation carrying capacity should be concurrently addressed. It should be expected that the related recreation facilities will not affect the everlasting use of the resources.

4. Social Relation

Currently, the opportunities provided in the area are mainly landscape enjoyment, sightseeing, picnicking and barbecuing, camping, mountain climbing and hiking. Among these, mountain climbing and hiking have the least affect on the quality of the recreational experience. In the future, a set of recreational models should be designed to satisfy different social needs under the condition of not damaging the landscape resources in accordance with tourist demands.

5. Acceptability of Tourist Impacts

Ta-keng Scenic Area is planned to provide recreational opportunities of leisure enjoyment, picnicking and barbecuing, camping, mountain climbing and hiking, etc. for the people of the central region of Taiwan. In this type of area the degree of land development will be comparatively massive. It is desirable to adequately protect the more sensitive areas and improve the other areas with good planning and facilities to provide high quality recreational opportunities.

6. Acceptable Systemised Management

As the management of the area is mainly aimed at providing higher quality recreational opportunities, service facilities must be strengthened for the time when recreation demand will increase in the future to prevent resources from suffering unacceptable damage. Nevertheless, it is advisable to take indirect measures to avoid hurting the quality of tourists' recreational experiences.

7.6.3 <u>Development Constraints of the Area</u>

1. Related Plans and Acts

When a plan of recreation resources development is done, it would go along with existing regulations, so that the planning will have a practical effect. The related plans and restricting regulations which affect the development of Ta-keng Scenic Area entail construction and management, water and soil retention and land-use. The related articles are shown in Table 7.14.

2. Natural and Manmade Environment

(1) Slope Gradient and Direction

The slope gradients of the area vary

considerably. Slopes under 30% in gradient occupy 30.31% of the area, while those more than 40% in gradient occupy 61.69%. Based on considerations of engineering safety and geological stability, if a suitable development is made on convex slopes of 30% (about 22%) or slopes of 30% concave to 40% (about 22%-27%), there would be no big problems caused. Nevertheless, if development is made on direct slopes of 30% to more than 40%, there is a risk of land sliding, basement sinking and safety worries.

(2) Soil and Geology

Generally, the main geological structure of the area is Tou-ko Mountain stratum, Hsiang-shan phase, low in cohesion and load capacity. Its stability can be maintained if it is not disturbed. But if it is to be developed, a detailed survey of the direction and dip of the strata has to be taken and improper slope shaping should be avoided. The depositional terraces in the northeast of the area are favourable for development, because the heavy weight which can be carried by the rock strata can be transmitted through gravel. Thus the load capacity is high and it has an advantage for cultivation. As for the sedimentary strata spreading over the river valley and flood plain, the stability of the strata and safety measures of draining and damming should be considered to assure the safety of the running water, if these areas are to be developed.

(3) Hydrology and Drainage

Whether the drainage of the hillsides is proper greatly affects the safety of hillside development. The formation of hillside disasters is mainly caused by heavy rainfall. In the Scenic Area, precipitation is greatly concentrated and soil types do not have high water retention. Also, because of the steep terrain and loose soil structure, parts of the area seriously suffer from erosion. Therefore, provided that facilities are to be set up in the area it would be better to reduce the degree of development and avoid ground modelling and excavating that are not definitely necessary. In the meantime, better use should be made of engineering and vegetation measures to strengthen soil stability of the developed area, in order to reduce erosion. Additionally, the natural drainage system should be properly maintained.

The drainage function of the natural terrain should not be damaged and plenty of artificial drains should be established in accordance with the terrain. The period of construction should avoid the heavy summer rainfall season, so that the mud and land slides and heavy sedimentation can be reduced to the minimum.

(4) Microclimates

The trend of hills and direction of streams in the region are generally west to east. The hills intercept the south wind in summer and the north wind in winter. The windward slopes in summer are also the leeward slopes in winter. Due to the fact that ridges mostly run west-east and the topographic trend rises higher to the northeast, the slope aspects are mostly southward, while westward aspects are second. Therefore, in terms of the load capacity, it is better to situate buildings on southward or westward slopes. Recreational facilities should be situated on southwestward, southward or eastward slopes which receive back-winds and can partly receive sunshine.

(5) Plants

The flora in the area, being greatly influenced by the terrain, are classified into two categories. The gradual slopes of which the gradient is below 40% are mostly cultivated. Those above 40% in gradient are still kept in the primitive situation of forest.

The appearance of the latter are esthetically pleasing and they have a vital function in water and soil retention. Therefore, the protective forests on steep and those along side the natural drainage channels should be given proper protection in the future development of the area.

(6) Transportation

The existing roads in the area, being limited by the natural terrain, frequently have steep gradients. The surface conditions of the roads are frequently only roughly graded. There are increased risks in driving. Furthermore, due to the lack of an overall road system in the area, the planning of the future transportation system which connects with the other recreation sites, will be one of the main concerns.

7.6.4 Development Potentials of the Area

In consideration of the natural and human-cultural characteristics, development potentials and limits of ecological factors of the scenic spots described above, it is known that parts of the area are suitable for recreational facilities and construction development, while other parts are not. The area is to be categorised into five classes according to development potentials and suitability of land-use. (Table 7.15)

1. Areas with the Most Development Potential

Slopes under 15% in gradient; nonnatural drainage areas; depositional terraces in geology, with southward, southeastward or southwestward aspects; ample sunshine, without suffering winter seasonal winds; good accessibility and with aesthetic landscapes; are to be listed as the areas with the most development potential. These areas can be used as service centres, parking lots, camping sites, etc. But plenty of consideration still has to be given to water and soil retention and the requisite engineering safety measures.

2. Areas with Average Development Potential

All the windward slopes in winter with a gradient below 15% and those facing the summer seasonal wind with a gradient between 16% - 30%, nonrunning surface water zones, fair in accessibility underlain with Tou-ko Mountain stratum or depositional terrace strata, will be listed as the areas with average development potential. These areas

Table 7.15 Development Potentiality Analysis

Development Potentiality	Natural, Human-Cultural Environment Charateristics	Land-use Suitability
Areas with most development potential	Having at the same time . Gradient below 15% . Nonnatural drainage . Geology of depositional terrace strata . Ample sunshine . Not exposed to winter seasonal winds . Aesthetic landscape . High accessibility . Reserve land for further development	Transportation facilities, Large-scale public facilities
Areas with average development potential	. Windward slopes in winter, with a gradient below 15% or those facing summer seasonal winds with a gradient between 16% - 30% . Nonrunning water zones . Fair accessibility	Public facilities, Recreation facilities
Areas with minor development potential	. Windward slopes in winter, with a gradient between 16% - 30%; or those facing summer seasonal winds, with a gradient between 31% - 45% . Nonrunning surface water zones . Sparse and widely scattered settlement . Poor accessibility	Minor transportation facilities, Leisure facilities, Suitable for small-scale development
Areas without development potential	. Gradients above 45% . Geology of sedimentary strata . Inconvenient accessibility . Little settlement . No reserve land for further development	Service vehicle, Footpath Leisure facilities, Suitable only for partial development
Restricted development areas	. Within running surface water zones . Plant community with aesthetic appearnace and having a water & soil retention function . Mixed plant communities	Recreation facilities, without damaging the existing ecology Suitable only for small-scale, minor development

are not suitable for large-scale development, but can be used in the layout of public recreational facilities.

3. Areas with Minor Development Potential

All the windward slopes in winter with a gradient between 16% - 30% and those facing the summer seasonal wind with a gradient between 31% - 45%, and nonrunning surface water zones are listed as the areas with minor development potential. They are suitable only for small-scale development.

4. Areas Without Development Potential

Slopes with a gradient above 45%, underlain with sedimentary strata, sparse in settlement, inconvenient in accessibility, with no reserve land for further development are listed as areas without development potential. Their development is only partially allowed, such as for minor transportation and layout of leisure facilities.

5. Restricted Development Areas

Areas within running water zones or mixed plant communities and aesthetic appearance, and areas with plant communities which have water and soil retention functions and aesthetic appearance, should be listed as restricted areas, and given proper protection. If it is absolutely necessary to develop (for walkways, pavilions, viewing towers, recreational installations, etc.), then the degree of development should be kept as low as possible, so that it would not affect the ecological environment.

7.7 Land-use Suitability Analysis

7.7.1 Planning Goals and Criteria

Planning goals and criteria are made in accordance with the analysis of the factors which affect the development of Ta-keng Scenic Area. Based on the criteria, every strategy pursued and then the land-use zoning plan is drawn up. The planning goals, criteria and strategies are as follows: (Table 7.16)

7.7.2 Land-use Plan

Land-uses differ in accordance with the different types of recreational resources available. According to the planning objectives and criteria of Ta-keng Scenic Area, considering the feasibility for future development and taking 200 x 200 m^2 as the basic unit of measurement, then the resource characteristics of each unit can be analysed. By integrating resources which are homogeneous, the future land-uses of Ta-keng Scenic Area are divided into eight types (the X in the formula in Chapter Six). The resource characteristics and different land-uses are explained as follows (Fig 7.9):

1. Mountainous Zone.

This indicates areas that have not been disturbed by people and still keep their forest appearance. The main resources are mountains, with a few scattered settlements. The best suggestion is to conserve this area rather than to

Table 7.16 Planning Goals, Criteria and Strategies

Planning Goals	Criteria	Strategies
1. To conserve the natural environment, make best use of the natural resources and maintain ecological balance.	(1) To maintain and make effective use of the natural landscape and enhance the character of the hillside landscape.	a. Make best use of the visual landscape. b. Make effective use of existing flora. c. Plan and design in accorance with existing terrain.
	(2) To match with acts & related plans and make proper use of the available resources.	a. Agree with existing acts and related plans. b. Consider the environmental characteristics, social factors and costs-benefits.
	(3) To reduce manmade demage.	a. Areas prone to landslide or collapse should be planned as protected areas to restrict their development. b. Avoid developing along ridge lines. c. Avoid large-scale development and make adequate development. d. Natural resources which already have been developed or damaged should be improved and maintained.
	(4) To conserve & improve the existing vegetation and uplift the diversity of the hillside ecology.	a. Maintain natural drainage systems. b. Avoid changing the present terrain if possible. c. Avoid developing those vegetation areas that are growing well and which have the function of land retention. d. Mesh with the needed function of introducing plants suitable to the ecological requirements of the area, and use locally indigenous plants e. Use vegetative slope protection to maintain and beautify exposed and collapsed slopes.

Table 7.16 Planning Goals, Criteria and Strategies (Contd.)

2. To improve recreation quality, enrich recreation experience and develop tourism.	(1) Mesh the regional with the island recreation system and provide variety of recreational of enjoyment.	a. Maintain the present landscape and characteristics. b. Develop the existing traits of each recreation spot within the area. Emphasise the linkage between spots. c. According to traits of each recreation spot and tourist routes of the Central Region of Taiwan, plan half-day, one-day, and two-day trips.
	(2) Enhance the participation, knowledge and recreation experience of tourists' recreational activities.	a. Uplift the quality, variety, and interest of the related production recreation activities to increase the attraction for tourist activities. b. Along with folklore and farmers' festivals, provide dynamic & static activities and interpretation facilities, either indoor or outdoor.
3. To promote the local economy & increase resident's welfare.	(1) Improve residential environmental quality & enhance residents' quality of life.	a. Mesh with the establishment of the recreation system, construct parking lots, water-supply systems, and service facilities. b. Construct road system, taking care of local development and tourist profits at the same time. c. Harmonise with the terrain, provide dwellings.
	(2) Increase local employment opportunities.	a. Encourage farmers' participation in tourism investment and management b. According to proper type of management, provide local resident's lodging for tourists and other commercial activities.
	(3) Increase the profit of agricultural production.	a. Cooperate with productive industry & recreational activities and provide on site direct-sale opportunities.

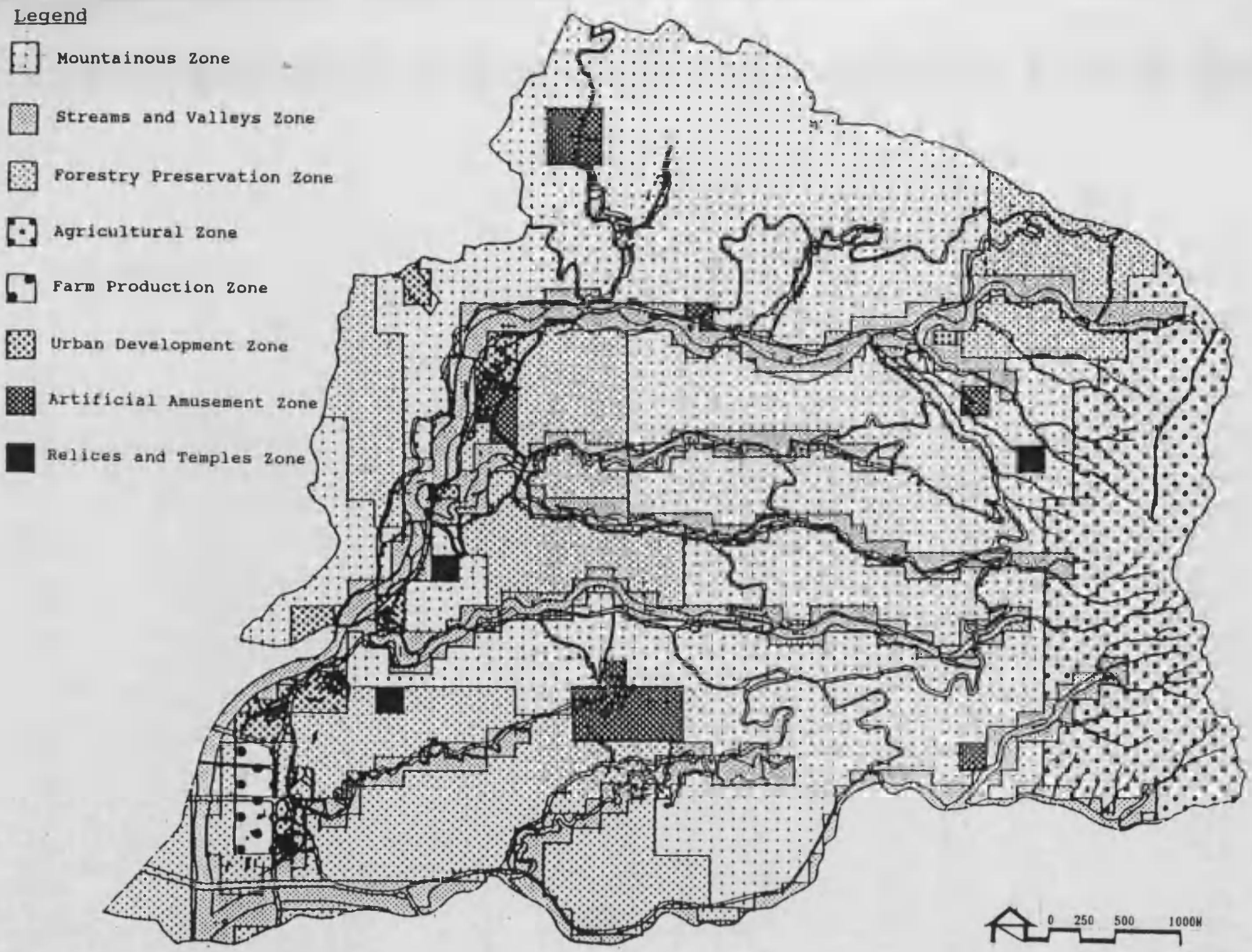


Figure 7.9 Land-use Zones of Ta-Keng Scenic Area

develop it in the future.

2.Streams and Valleys Zone.

Rainfalls are abundant in Ta-keng district during rainy seasons. But due to the great variation in terrain and poor water retention capacity of the soil, streams usually almost dry up between rains, while they rush in torrents during and immediately after heavy rains. Thus streams are mainly suitable for conserving, yet, they could be used for seasonal recreational activities during the nonrainy seasons.

3. Farm Production Zone.

In this area, production could be divided into bamboo, rice, vegetables and fruits. Among these, vegetable and fruit plots occupy most of the area. Fruit trees are of numerous kinds and yield in different seasons. Under conditions of labour shortage today, vegetable and fruit plots can provide visitors with fruit picking, tasting, picnicking and landscape observation activities through proper management. This will not only satisfy visitors with enjoyment of rural life, but it can also provide some education during entertainment.

4. Forestry Preservation Zone.

This area is located at the east side of Ta-keng Scenic Area. It is a National Preservation Forest with an altitude of 500 to 800m. The average gradient is more than

45%. The mountains occur in series. All main streams in Ta-keng Scenic Area have their sources here. The forest itself has functions of water and soil retention and ecological stabilisation. Currently, there are one camping site and five mountain climbing footpaths scattered within the area. For future development, it is suggested that, except for constructing more footpaths and observing towers, other activities that could destroy or damage the natural appearance should be strictly forbidden.

5. Agricultural Zone.

There are few plains in Ta-keng Scenic Area. Because water sources are not easy to obtain, only in the west plain are there rice fields, which exhibit an agricultural landscape. However, since the area is adjacent to the future urban development area, the rural recreation activities it can provide is comparatively low, except for the visual amenity of being an agricultural landscape. Thus the suggestion is made here that it be maintained for agricultural production, as it is now.

6. Urban Development Zone.

In the Scenic Area, there are settlements, hotels, schools, public institutions, markets, parkgreens, parking lots and children's playground already available. These places are either comparatively extensive or possess great development potential. Therefore, it is expected that in the future, under the relevant acts and codes and within the future, under the relevant acts and codes and within the limits of the built-up rate and bulk rate of the built-up areas, these places can be further developed as urbanised areas.

7. Artificial Amusement Zone.

At present, the artificial amusement areas which have been developed in the Scenic Area are Encore Garden, Cartory Amusement Park and others. As these activities and installations are often duplicates of other similar places in Taiwan and are short of public facilities and local flavour, the ability to compete in the tourist market is weakened and there is not enough to attract many visitors. It is, therefore, suggested that the main existing activities should remain as the principal recreational resources, but they should be strengthened. The newly-provided activities have to be participated in concurrently with the visual amenity functions, so to enhance the recreational experience.

8. Relics and Temples Zone.

Within the Scenic Area, there are many temples whose architectural forms are different from those of common buildings. The best example is Sheng-shou Temple of which the building itself is gorgeous, facing streams and next to mountains. With the graceful picturesque scenery, this temple is an important religious tourism spot. It is, therefore, suggested that those temples which have larger areas and better surroundings should be properly planned, corresponding to festival and folklore activities to enhance the recreation quality.

7.7.3 Analysis of Suitable Activities and Facilities or Each Zone

From the land-use analysis made of each zone, it is known that some resources are only used for a single recreational activity, while some are used for multiple purposes. In terms of the mutual relations among recreational activities, there is mutual tolerance, irrelevancy or mutual repulsion (Table 7.11). The requirements of each activity made on resources are different. If they can be well planned, then one kind of resource can provide several activities at the same time, i.e., a multipurpose resource.

Installations needed for recreation activities can generally be divided into recreational and public facilities, educational and safety equipment. The proper activities and the facilities needed for each zone are classified according to the analysis in paragraph 7.3.3. Further those activities which are mutually tolerant are assigned to one category as subzones (variable Xij in the formula of Chapter Six).(Table 7.17) Apart from the urban development area which is excluded in this study, the rest of seven zones and twenty eight subzones totalled about 32,440,000m^2 in area are considered as the preliminary land use plan of Ta-keng Scenic Area. (Table 7.18) They are to be used as the basis for the measurement of recreation carrying capacity and for the phasing in schedule and financial plan which are to be discussed in the following chapters.

Table 7.17 Land-use Zone and Suitable Activities with Facilities

Zones	Suitable Activities	Facilities Needed	Subzones
1. Mountainous Zone	mountain climbing, hiking, physical training, camping, lanscape observation, nature sightseeing, picnicking barbecuing	mountain climbing footpath, seats, viewing tarrace, pavilion, barbecuing facilities, sanitary facilities, wastes treatment installations, kiosk, car park, telephone, safety installations, interpretation facilities water and eletricity facilities.	Preservation Area X1,1 Physical Training Field X1,2 Camping Site X1,3 Picnicking and Barbecuing Site X1,4 Mountain Climbing Footpath X1,5
2. Streams and Valleys Zone	mountain climbing, hiking, physical training, landscape observation, picnicking, barbecuing, swimming, camping.	footpath, physical training facilities, barbecuing facilities, sanitary facilities, wastes treatment installation, playgrounds, telephone, safety installations, interpretation facilities, water supply and electricity facilities.	Preservation Area X2,1 Physical Traning Field X2,2 Camping Site X2,3 Picnicking and Barbecuing Site X2,4 Mountain Climbing Footpath X2,5
3. Farm Production Zone	mountain climbing, hiking, physical training, landscape observation, nature sightseeing, picnicking, barbecuing, fruit picking, grass skiing, horse riding.	footpath, seats, service facilities, safety installations, sanitary facilities, wastes treatment installations, telephone, water supply and electricity facilities.	Preservation Area X3,1 Physical Training Field X3,2 Picnicking and Barbecuing Site X3,4 Mountain Climbing Footpath X3,5 Orchard Area X3,6 Horse Riding Field X3,7 Grass Skiing Field X3,8

Table 7.17 Land-use Zone and Suitable Activities with Facilities (contd.)

4. Forestry Preservation zone	mountain climbing, hiking, landscape observation, nature sightseeing.	footpath, seats, viewing terrace, pavilion, safety installations, interpretation facilities.	Forestry Preservation Area. X4,1 Mountain Climbing Footpath X4,5
5. Agricultural Zone	landscape observation, picnicking, barbecuing, bicycling.	footpath, barbecuing facilities, pavilion, safety installation.	Farmscape Preservation Area X5,1
6. Urban Development Zone	lodging, shopping, working, schooling. playing, recreation, etc.	road, sanitary facilities, post office, telephone, car park, public transportation, restaurant, hotel, private house, hospital, administration office, wastes treatment installations, market, water supply and electricity facilities.	Residential Area X6,9 Park, Green-field X6,10 Office, School, Institution X6,11 Hotel and Restaurant X6,12
7. Artificial Amusement Zone	landscape observation, picnicking, barbecuing, artificial amusement, grass skiing, driving fruit picking, swimming, paddling.	road, footpath, exhibition hall, path, water feature, sculpture, mechnical play equipment, tourist centre, car park, sanitary facilities, water supply and electricity facilities, telephone, wastes treatment installation.	Picnicking & Barbecuing Site X7,4 Tourist Orchard Area X7,6 Grass Skiing Field X7,8 Mechanical Play Equipment Area X7,13 Tourist Centre Area X7,14 Garden X7,15
8. Relics and Temples Zone	temple visiting, landscape observation, forklore activity.	road, car park, administration, office, sanitary facilities, water supply and electricity facilities, telephone, wastes treatment installation, temple, pavilion.	Temple & Relice Area X8,16 Forklore Activity Area X8,17

Table 7.18 Preliminary Land-use Plan of Ta-Keng Scenic Area

Zone	Sub-zone (m^2)	
X1	Preservation Area(X1,1)	13,413,600
	Physical Training Field(X1,2)	243,400
	Camping Site(x1,3)	507,300
	Picnicking & Barbecuing Site(X1,4)	318,300
	Mountain Climbing Footpath(X1,5)	67,400
X2	Preservation Area(X2,1)	5,424,300
	Physical Training Field(X2,2)	205,000
	Camping Site(X2,3)	204,700
	Picnicking & Barbecuing Site(X2,4)	331,000
	Mountain Climbing Footpath(X2,5)	135,000
X3	Preservation Area(X3,1)	4,714,000
	Physical Training Field(X3,2)	469,300
	Picnicking & Barbecuing Site(X3,4)	165,500
	Mountain Climbing Footpath(X3,5)	124,000
	Orchard Area(X3,6)	721,500
	Horse Riding Field(X3,7)	431,700
	Grass Skiing Field(X3,8)	374,000
	Forestry	
X4	Preservation Area(X4,1)	3,514,000
	Mountain Climbing Footpath(X4,5)	86,000
X5	Farmscape Preservation Area(X5,1)	200,000
X7	Picnicking & Barbecuing Site(X7,4)	125,600
	Tourist Orchard Area(X7,6)	67,100
	Grass Skiing Field(X7,8)	80,100
	Mechnical Play Equipment Area(X7,13)	161,000
	Tourist Centre Area(X7,14)	73,600
	Garden(X7,15)	132,600
X8	Relice and Temple Area(X8,16)	60,000
	Forklore Activity Area(X8,17)	90,000
Total		32,440,000

X1 : Mountaneous Zone

X2 : Streams and Valleys Zone

X3 : Farm Production Zone

X4 : Forestry Preservation Zone

X5 : Agricultural Zone

X7 : Artificial Amusement Zone

X8 : Relices and Temples Zone

REFERENCES

1. Taichung City Government : "First Review Instruction for the Master Plan of Changing Taichung City Urban Plan (Ta-Keng Scenic Area)". (in Chinese), A Report of Taichung City Government, Taichung, Taiwan, ROC, 1988, pp. 9-12.

2. Agriculture College, National Taiwan University : "A Detailed Plan Instruction of Ta-Keng Scenic Area of Taichung City". (in Chinese), A Report to the Taichung City Government, Taichung, Taiwan, ROC, 1985, p. 8.

3. Ibid 1, pp. 19-26.

4. Ibid 1, pp. 13-19.

5. The Department of Urban Planning, Feng Chia University : "A study on the Recreation System of Taiwan". (in Chinese), A Report to the Tourism Bureau, Taiwan, ROC, 1988, p. 126.

6. Taiwan Provincial Government : The Central Regional Plan of Taiwan". (in Chinese) Taiwan Provincial Government, 1971, pp. 129-267.

7. Wang, Hsiao Lin and Yu Feng Ho : "A Study on Ta-Keng Tourism Farm Village Planning". (in Chinese), A Report to the Taichung City Government, Taichung, Taiwan, ROC, 1989, pp. 79-81.

8. Yu, She Yung : "Topology". (in Chinese), North Sea Publishing, Taipei, ROC, 1955, pp. 81-84.

9. Feng Chia University : "Taichung City Tourism Development Comprehensive Plan". (in Chinese), A Report to the Taichung City Government, Taichung, Taiwan, ROC, 1988, pp. 3-11, 3-34.

10. Ibid 9, pp. 3-32.

11. Ibid 9, pp. 3-11, 3-12.

be used as the basis for the measurement of recreation carrying capacity and for the phasing in schedule and financial plan which are to be discussed in the following chapters.

CHAPTER 8

RECREATION CARRYING CAPACITY OF TA-KENG SCENIC AREA

8.1 Introduction

According to the recommended method suggested in section 6.3 of Chapter Six, it is known that the recreation carrying capacity is one of the main factors to be considered in the land-use plan of a recreation area. This chapter discusses the measurement of the social-psychological and physical-ecological carrying capacities of Ta-keng Scenic Area.

8.2 Social-Psychological Carrying Capacity

8.2.1 Questionnaire Method

1. Questionnaire Purposes

The two main purposes of this part of the study are, first, to find out the characteristics of the visitors who visit Ta-keng Scenic Area and their perception of crowdedness, and perception of tolerance as the measure of social-psychological carrying capacity. Second, to understand visitors' motives, satisfaction, intentions and reasons to revisit and expectations of the future development planning of Ta-keng Scenic Area.

2. Questionnaire Design Method

The questionnaire in the study for the social-psychological carrying capacity used the closed type of structured questionnaire. That is, visitors choose from among the well organised answers of the previously designed questions. The procedure for the questionnaire design is as follows:[1]

(1) Determine the contents and scope of the questionnaire, according to the study purposes and information needed.

(2) Determine the type of questionnaire--in the present study, closed questionnaire of the structured type--according to the purposes and nature of the study, make the questionnaire conform to the needs of the interviewees and to facilitate later manipulation of the data.

(3) Draw up and test the questionnaire. The testing is to find out and correct any irrational items in the contents, in order to increase the reliability of the questionnaire results.

(4) Select the data: Use weekdays, routine holidays and special holidays to have a representative sample in order to increase the validity of the questionnaire.

(5) Apply statistical methods to find out the needed information.

3. Questionnaire Contents (Appendix 8.1)

Factors which affect the social-psychological carrying capacity include psychological traits of tourists, social environment of the recreation area, natural environment of the recreation area and the nature of the recreation activities. (See Chapter Four, section 4.3.2) Considering the first two factors above, along with the characteristics of the study area, the present questionnaire formulates the contents as follows:

(1) Visitors' basic data: gender, age, educatinal background, occupation, address, accompanying group, organisation, group size, transportation method and willingness to spend.

(2) Visitors' perception of crowdedness, maximal limit of crowding tolerance and the time of crowding awareness during the activities undertaken in the area.

(3) Visitors' travel motives, outcome and the reason unwilling to revisit.

(4) Visitors' satisfaction of the travel and intention to revisit.

(5) Visitors' attitude toward the future development of Ta-keng Scenic Area.

4. Hypotheses and Conditions of Questionnaire.

The design and implementation of the questionnaire are formulated under the following hypotheses and conditions:

(1) During the visit, visitors have a considerable degree of physical and mental experiences of , and reactions to, the existing facilities, the behaviour of other visitors and disappointment caused by differences between expectations and actual conditions.

(2) The recreation opportunities provided by recreation site undertaken by the questionnaire are the same as that provided by the other sites of the study area with similar characteristics.

(3) There are many factors which affect visitors' satisfaction. (See Chapter Four, section 4.3.2.) Therefore, social-psychological carrying capacity is not easily measured by visitors' degree of satistaction and visitor density. Increase in visitor density or frequency of contact will lead to increase in visitor density or frequency of contact will lead to increase crowding awareness and further affect the recreational experience. Therefore, this study takes the maximal visitor density that is tolerated by visitors and the number of visitors' that feels crowded as the indicator along with other relevant factors to analyse social-psychological carrying capacity.

5. Implementation of Questionnaire.

(1) Time

The questionnaire was carried out for each recreation activity. One day was selected from among weekdays, routine holidays and special holidays. The questionnaire was conducted continuously from 8:00 am to 5:00 pm. In case of rain, it was postponed one day for weekdays or one week for routine days, while the coming special holiday would be chosen instead. The time schedule is shown in Table 8.1.

(2) Place

The study takes existing recreation sites in Ta-kerg Scenic Area and assigns them to the homogeneous categories according to the analysis results of land-use suitability described in section 7.7 of Chapter Seven. Eight spots and activities that are representative were selected for the questionnaire. These spots and activities are listed in Table 8.2 and Figure 8.1.

Table 8.1 Time Schedule for Visitors' Social-Psychological Carrying Capacity Questionnaire

	Date
Weekday	Feb 2, 1989 (Thusday)
Routine Holiday	Feb 19, 1989 (Sunday)
Special Holiday	Feb 12, 1989 (Chinese New Year)

Table 8.2 Places Surveyed for Visitors' Social-Psychological Carrying Capacity

Recreation Spots	Main Activities	Homogeneous Places
Sheng-shou Temple	Temple Visiting	Pao-an Temple Yu-Fo Temple
Ta-keng Physical Training Field	Physical Training Picnicking & Barbecuing	Lebanon Villa Green Field Villa
Ta-keng Mountain Climbing Footpath	Mountain Climbing & Hiking	
Cartory Amusement Park	Artificial Amusement	Venice Floating Amusement Park
Chungcheng Camping Site	Camping Picnicking & Barbecuing	
Encore Garden Gate	Landscape Observation	
Inside of Encore Garden	Landscape Observation	Taichung Tourist Farm, Tangshan Amusement Park

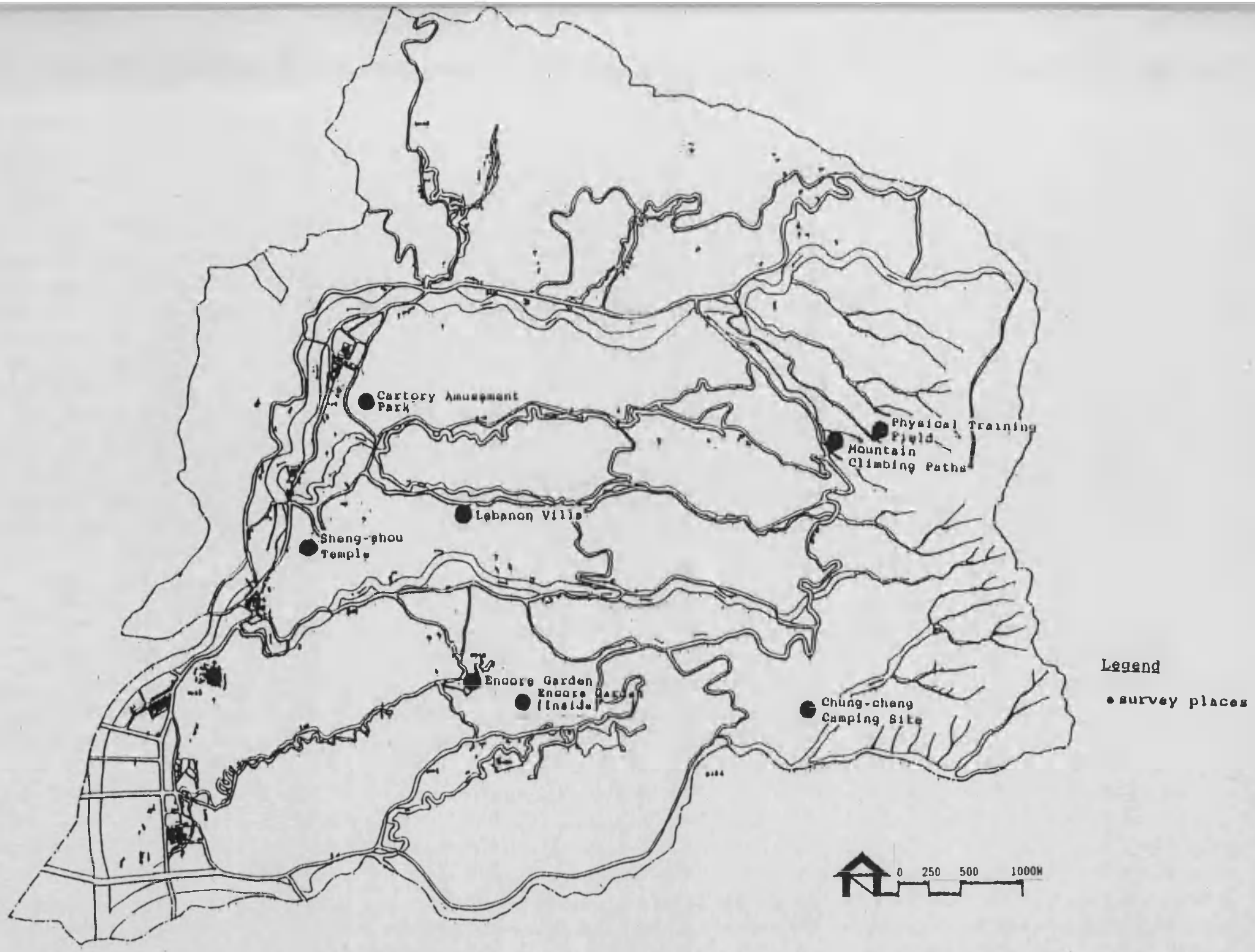


Figure 8.1 Recreation Carrying Capacity Surveyed Places of Ta-Keng Scenic Area.

(3) Sampling and Execution.

In order to obtain more objective and representative results, the questionnaire in the study employs the random sampling method. That is, it uses interviews of visitors appearing at random places and at random times. In other words, during the course of sampling, the interviewees were not prearranged, so that each visitor had an equal chance to be interviewed.[2] Questionnaire was carried out by having two interviewers as a team interview visitors face to face. In case visitors had any suggestions or other replies, they were recorded for later analysis.

(4) Response Rate

The questionnaire proceeded for three days producing 1,271 interviews. The response rate was 100%, out of which 13 copies were invalid, 1,258, valid. the valid questionnaire rate was 99%. (Table 8.3)

6. Analysis of Questionnaire

The social-psychological carrying capacity in this study is measured by using the visitor's perceptions of crowdedness and tolerance as its indicator and matching with the analytical results of other factors concerned. Therefore, the questionnaire information was divided into the following three steps:

(1) Classification of the Basic Data

Making classification and statistics to the questionnaires collected back based on time, spots and

Table 8.3 <u>Social-Psychological Carrying Capacity Questionnaire Response Status</u>

Number of Questionnaires / Date		Feb.2,1989 (Weekday)			Feb.12,1989 (Special Holiday)			Feb.19,1989 (Routine Holiday)		
Places	Activities	A	B	C	A	B	C	A	B	C
Sheng-shou Temple	Temple Visiting	56	0	56	86	0	86	65	0	65
Ta-keng Physical Training Field	Physical Training	22	0	22	100	0	100	46	0	46
	Picnicking & Barbecuing	0	0	0	19	0	19	15	0	15
Ta-keng Mountain Climbing Footpath	Mountain Climbing & Hiking	25	0	25	66	0	66	48	0	48
Cartory Amusement Park	Artificial Amusement	63	0	63	30	0	30	50	0	50
Chungcheng Camping Site	Camping	36	1	35	5	0	5	34	1	33
	Picnicking & Barbecuing	0	0	0	62	0	62	33	1	32
Encore Garden Gate	Landscape Observation	73	2	71	85	3	82	60	0	60
Inside of Encore Garden	Landscape Observation	71	2	69	55	0	55	66	3	63
Subtotal		346	5	341	508	3	505	417	5	412
Total	Total Number of Questionnaire 1,271			Total Number of Invalid Questionnaires 13				Total Number of Valid Questionnaires 1,258		

A = Number of Questionaires

B = Invalid Number of Questionnaires

C = Valid Number of Questionnaires

activities.

(2) Single Item Analysis

Based on the contents of the questionnaire, single item statistics and analysis are made to the visitors basic information, perceptions of crowdedness and tolerance, travelling motive outcome and the reason of being unwilling to revisit, satisfaction degree and willing of revisit, developing expectation, etc. All of these are to be as reference for the measurement of social-psychological carrying capacity.

(3) Cross-analysis

By using Chi Square method to make cross-analysis to two single items to check the relationship between them.

8.2.2 Observation Method

1. Purposes of the Questionnaire

The purpose is to distinguish the different levels of perceptions of crowdedness and tolerance applying to the social-psychological carrying capacity. Furthermore, its purpose is to understand the changing situation of visitors, the number of visitors and groups and the relationship between visitors' experience and recreation carrying capacity on weekdays, routine holidays and special holidays at Ta-keng Scenic Area.

2. Observation Method

The study adopted the structured and nonparticipant natural observation method to observe visitor frequency change and to make a systematic record.[3] Apart from the two-interviewer teams dispatched at every recreation site for observation and recording, the study made use of photography to check or supplement the record, to maintain observation objectivity and precision.

3. Definition and Hypotheses

The study is constructed on the following definition and hypotheses:

(1) Number of visitors: Use the largest number of visitors appearing in a time-unit as the counted number.

(2) Visitors' groups: If observed visitors include more than two individuals, the nature of their activities are the same, the area for their recreation activity partially overlapped, their activities interact and their conversation lasts comparatively long, then they are considered to constitute a group.

(3) In case the individual visitors or visitor groups reappear at the same place, they still will affect the perception of crowdedness, so their visitor-frequency is also counted.

4. Implementation of Observation

Observations were made at the same time as questioning. But the time of day for observation varied for the various recreation activities. Mountain climbing was observed from 5:00am to 17:00pm, while other activities were from 8:00am to 17:00pm. Every 30 minutes was a record-unit for recording the number of individual visitors and groups in a time-unit, in order to understand the variation of the number of visitors and groups within a day. (Appendix 8.2)

8.2.3 Combined Analysis and Results of the Questionnaire and Observation of Visitors' Activities

The analytical results are discussed in relation to two parts:---the data needed for measuring social-psychological carrying capacity and visitors' opinions of the future development of Ta-keng Scenic Area.

1. Part I: Data Needed for Measuring Social-Psychological Carrying Capacity

(1) General Description

The analysis is based on the basic data of visitors' recreation activities and perceptions of crowdedness and tolerance collected from the 1,258 valid copies of the questionnaire.

i. Visitors' basic data (Appendix 8.3, Table 1)

a. Gender : The majority of visitors are males, accounting for 55.7%, while females account for 44.3%.

b. Visitors' ages : ages 15 to 44 account for 81%, among these, age 15 to 24 account for 41.9%. This indicates the main age level tends to be young. In other words, visitors are mostly teenagers; visitors older than 64 are the fewest, accounting for only 1.4%.

c. Visitors' educational background : most are senior high or vocational school students, accounting for 45.4%. Second are college or university students, at 32%; last are junior high students, at 15.8%.

d. Visitors' careers : most are students, accounting for 40.2%; second are businessmen, at 19.3%; farmers, fishermen and ranchers are the least, at 1%.

e. Visitors' dwelling places : most are Taichung city dwellers, totalling 48.9%, almost half the total visitors. Next is Taichung county, providing 16.7%. Thus visitors from Taichung city and county amount to 65.6% of the total. This indicates that Ta-keng Scenic Area serves mainly the Central Region of Taiwan. Visitors from the southern cities and counties account for 14.7% which is more than those from the other cities and counties of the Central Region, at 11.2%.

f. Companions : most are family members or other relatives, accounting for 43.6%. Next are friends or colleagues, accounting for 28.9%; schoolmates, at 20.7%; "no companions" are the least, amounting to only 2.4%. This indicates that those travelling with relatives and friends total 72.5%.

g. Number of companions : most groups have 2-5 persons, accounting for 47.1%. Second is 6-10 persons, at 18.6%; and groups of 21-40 persons are the fewest, at 2.1%. This indicates that visitors are mostly organised in small groups.

h. Transportation : most are private cars, totaling 48.6%. Second are motorcycles, accounting for

23.2%; next are public buses, at 14.5%; bicycles are the least, at 0.6%.

i. <u>Visitors' willingness to spend</u> : The vast majority of visitors are willing to spend no more than N.T.$1,000. Among these, visitors willing to spend up to N.T.$300 account for 37.9% of the visitors. Second is N.T.$301-500 willing to be spend by 22.8% of the visitors; N.T.$701-1,000 accounts for 15.8%. Only 2.9% of visitors are willing to spend N.T.$1,051-2,000.

ii. <u>Recreation Activities</u> (Appendix 8.3, Table 2)

a. Main visitor activities include "landscape observation", which accounts for the highest percentage (31.7%); "temple visiting" totals 16.5%; "artificial amusement", 11.4%; "physical training", 13.4%; "mountain climbing and hiking", 11%; "picnicking and barbecuing", 10.2%; and "camping" stands the lowest at 5.8%.

b. The number of visitor questionnaires distributed on special holidays was the most, totalling 40.1%. Second were those distributed routine holidays, accounting for 32.8%; those on nonholidays were the least, at only 27.1%. This indicates that most visitors are still taking special and routine holidays as their main time undertaking outdoor activities.

c. Visitor activity hours in a day are concentrated between 10:00-16:00, accounting for 73.2%. Within this period 10:00-12:00 accounts for 27.3%; 12:00-14:00 for 24.2%; and 14:00-16:00 for 21.7%. Activities before 8:00 are at the lowest. This indicates that most tourist activity is distributed quite evenly.

d. The momentary number of visitors during 11:00-12:30 within the area (for definition see 8.2.2.-3: Definition and Hypotheses), is the highest (22.31%). Others in order are 9:30-11:00 (18.46%), 15:30-17:00 (16.37%), 12:30-14:00 (16.33%), 14:00-15:30 (15.43%), 8:00-9:30 (10.59%), 5:30-8:00 (0.46%), and 17:00-17:30 (0.05%). The momentary number of visitors during 5:00-5:30 is the lowest. This indicates that although momentary number of visitors are not extremely high, the hours which carry the highest number of these visitors are concentrated during 9:30-12:30. The effects on the social-psychological and physical-ecological carrying capacities should not be neglected. (Appendix 8.4)

e. The largest number of the momentary visitor-groups (for definition see 8.2.2-3) within the area is during 11:00-12:30 (22.64%). The rest of the momentary visitor-groups in order are 12:30-14:00 (19.15%), 14:00-15:00 (17.56%), 15:30-17:00 (16.90%), 9:30-11:00 (16.49%), 8:00-9:30 (6.06%), 6:30-8:00 (1.11%) and 17:00-17:30 (0.07%). While the momentary number of visitors during 5:00-5:30 is the lowest (0.02%). This indicates that a large number of the momentary visitor-groups are concentrated during 11:00-17:00 (Appendix 8.4).

iii. <u>Perception of Crowdedness</u> (Appendix 8.3, Table 3)

a. Threshold number of persons at which visitors begin to feel crowded. The threshold number of persons in a unit area at which visitors begin to feel crowded varies with the type of recreation activity. For example, 23.5% of landscape observation visitors who begin to feel crowded are mostly concentrated in the 36-100 persons/ha category; 43.8% of visitors undertaking picnicking and barbecuing are within the less than 75 persons/ha category; 41.1% of campers are within the 51-75 persons/ha category; 22.4% of the artificial amusement visitors are within the more than 100 persons/ha category; 28% of the physical training visitors are within the 51-75 persons/ha category; 50.2% of the temple visitors are within the 76-100 persons/ha category; 25.2% of the mountain climbers are within the 11-20 persons/km category.

b. Tolerance of visitors density. Visitor tolerance of the density of other visitors varies according to type of activity. For example, 22.5% of the landscape observation visitors expressed tolerance for 101-150 persons/ha; 25.8% of the visitors involved in picnicking and barbecuing can tolerate more than 200 persons/ha; 23.3% of the campers indicated 51-75 persons/ha; 54.6% of the artificial amusement visitors indicated more than 200 persons/ha; 58% of the temple visitors indicated 76-100 persons/ha; and 26.6% of the mountain climbers and hikers indicated more than 50 persons/km.

c. The most preferred minimal distance, in metres, which must be kept between other visitors during activities so as to not feel crowded is 4-10m for 59.3% of the visitors.

d. The maximal tolerance of encounters frequencies with other visitors is 4-10 times per hour, accounting for 52.5% of the visitors.

e. There are two daily peaks of visitor frequency. They are 10:00-12:00, accounting for 22.3% of visitors and 16:00-18:00, at 25.2%; while 8:00-10:00 is the lowest, at 6.9%.

(2) Cross-analysis

i. Cross-analysis of each recreation activity and visitor characterstics (Appendix 8.3, Table 4) has been made. The results that have obvious relations are

a. Gender : Except for the landscape observation activity, the number of female visitors is slightly larger. In the other activities, males are in the majority. For male visitors, those involved in artificial amusement, physical training and mountain climbing and hiking are the largest in numbers. This indicates that most of females are still in favour of static activities while the reverse is true for males.

b. Age : Visitors undertaking landscape observation, picnicking and barbecuing, camping, artificial amusement and physical training are mostly under 25 years of age; the ages of visitors involved in mountain climbing and hiking are spread comparatively evenly.

c. Education : Visitors undertaking physical training and mountain climbing and hiking are mostly college students. Those involved in other activities are mostly senior high or vocational school students. This indicates that visitors' educations are related to their favourite wilderness activity.

d. <u>Career</u>: Temple visiting and mountain climbing activities are mostly taken by businessmen; others are mostly by students.

e. <u>Dwelling place</u> : Visitors, except for those involved in landscape observation and artificial amusement, mostly come from the southern cities and counties; for other activities, most come from Taichung City. This indicates the Scenic Area is mainly serving people of the Central Region of Taiwan.

f. <u>Companion composition</u> : Activities of landscape observation are mainly done with friends and colleagues; picnicking and barbecuing, physical training, temple visiting, mountain climbing and hiking are mostly done with family and other relatives, or alone; camping is mostly done with schoolmates and other social members; while artificial amusement is done mostly with schoolmates.

g. <u>Number of companions</u> : This varies according to the type of activity. For example, landscape observation, artificial amusement, temple visiting, physical training, mountain climbing and hiking are mostly carried out with 2-5 persons; picnicking and barbecuing mostly with 6-10 persons; while camping is done mostly with more than 20 persons.

h. <u>Transportation</u> : Visitors undertaking camping and artificial amusement mostly take public buses; other activities are mostly by private car. This indicates that, for the future development of the area, parking lots will be of greater importance.

i. Willingness to spend : Visitors for landscape observation and temple visiting are mostly willing to spend N.T.$701-1,000; those for camping are mostly willing to spend N.T.$301-500; others are willing to spend less than N.T.$300.

ii. Cross-analysis of each recreation activity with preferred interpersonal distance, maximal tolerance of encounters frequency and most crowded hours (Appendix 8-3, Table 5)

a. Preferred interpersonal distance : Visitors undertaking landscape observation and temple visiting, who prefer interpersonal distance should be kept at 7-10m are in the majority; visitors for picnicking and barbecuing, camping, artificial amusement and physical training mostly prefer 4-6m. Those involved in mountain climbing who prefer less than 3m account for 25.6%; but those mountain climbers who prefer 11-20m account for 23.3% and 21-30m account for 15.5%. This indicates that visitors in the latter activity exhibit great differences in preferred interpersonal distance.

b. Maximal tolerance of encounter frequency : Visitors undertaking artificial amusement, mountain climbing and hiking mostly have a tolerance of encounter frequency of more than 31 times; visitors for landscape observation and temple visiting mostly have a tolerance of encounter frequency of 6-10 times; those for camping and physical training, mostly prefer 4-5 times; and those for picnicking and barbecuing mostly prefer 2-3 times. This indicates the maximum tolerance of encounter frequencies of visitors differ extremely between the various recreation activities.

c. The most crowded hours : Mountain climbers mostly indicated that the most crowded hours are before 8:00; visitors for picnicking and barbecuing and physical training mostly think 10:00-12:00; for artificial amusement, 14:00-16:00; for landscape observation and temple visiting, 16:00-18:00; and for camping, after 18:00. This indicates that there is a close relationship between the type of recreation activity and the most crowded hours. Yet, most of the activities are undertaken before noon.

iii. Cross-analysis between recreation activities and visitor numbers (Appendix 8.3, Table 6).

The number of visitors for landscape observation is concentrated in the 101-300 persons category, while the number of visitor groups is 11-20. This indicates that the groups are smaller in scale in this activity. The number of visitors for picnicking and barbecuing, artificial amusement, physical training and temple visiting is concentrated in the 101-300 persons category; the number of groups are, respectively, 11-20, 3-10 and more than 20. This indicates that the groups are not large in scale. But those for camping are concentrated in the 51-100 persons and 1-2 groups. This indicates that camping activity is mainly for large-scale groups. Those for mountain climbing and hiking are mostly less than 50 persons and 3-5 groups, indicating the groups are larger in scale.

iv. Cross-analysis between perception of tolerance and visitor characteristics (Appendix 8-3, Table 7).

Perception of tolerance has no relation to visitor gender or educational background. However, visitors who are students expressed tolerance for under 75 persons/ha. Visitors under 25 years of age; Taichung City dwellers; those whose companions are family members or other relatives; single visitors and groups of 2-5 persons; those whose transportation is by private cars; those whose willingness to spend is less than N.T.$300; all of these categories have tolerance limits of visitor density at 26-100 persons/ha.

v. Cross-analysis between perception of crowdedness and visitor characteristics (Appendix 8-3, Table 8).

Perception of crowdedness has no statistical relation to visitor gender or educational background. Students under 25 years of age have a perception of crowdedness mainly concentrated in the 51-75 persons/ha category. Visitors with dwelling places in Taichung city or other cities or counties of the Central Region are mainly concentrated in 51-100 persons/ha; visitors from Taichung county are mainly in 76-100 persons/ha; visitors from southern counties or cities are mainly in less than 75 persons/ha; visitors from northeastern counties or cities are mainly in less than 50 persons/ha. Visitors with companions of family members or other relatives, or with companion are mainly in the 51-75 persons/ha category. Visitors in groups of 2-5 persons and those with transportation by private car are mainly in the 76-100 persons/ha category. Those with willingness to spend less than N.T.$300 tend to be in the 51-75 persons/ha category.

vi. Cross-analysis between visitor attitudes and perception of crowdedness and perception of tolerance (Appendix 8.3, Table 9).

Each kind of recreation activity has an obvious relation to visitor attitudes of perception of crowdedness and perception of tolerance. Except for landscape observation visitors, the remainder who have an attitude of wanting to maintain the natural landscapes also have a threshold of perception of crowdedness that begins at a lower number of people than that of visitors who have an attitude of wanting to develop recreational facilities. However, in terms of perception of tolerance, visitors undertaking picnicking and barbecuing, artificial amusement, physical training and temple visiting who have an attitude of "conserving" have nearly the same tolerance threshold as visitors who have an attitude of "developing". Visitors undertaking landscape observation and mountain climbing who have an attitude of "conserving" have a tolerance threshold lower than visitors who have an attitude of "developing".

vii. Cross-analysis between perception of crowdedness and perception of tolerance (Appendix 8.3, Table 10).

There is a close relationship between these two. As their Persons Rate equals 0.66263, then it shows that the existing linear correlation is a direct one and their correlationship is 66%. Therefore, in each recreation activity, the greater the perception of crowdedness, the higher the threshold of tolerance. The cross-analysis show that the following have statistical correlations:

a. Recreation activity with visitor characteristics (that is, the visitor's basic data);

b. Visitor age, dwelling place, companions, means of transportation and willingness to spend with the perception of crowdedness;

c. Visitor age, dwelling place, companions, means of transportation and willingness to spend with the perception of tolerance;

d. Visitor attitude with perception of

crowdedness and perception of tolerance;

e. Perception of crowdedness with perception of tolerance.

The following were found to have no statistical relation to each other:

a. Visitor gender and educational background with perception of crowdedness;

b, Visitor gender and educational background, with perception of tolerance.

viii. Cross-analysis of different holidays with perception of crowdedness and perception of tolerance (Appendix 8.3, Table 11).

On special holidays, the highest proportion of visitors feel crowded of 76-100 persons/ha; on routine holidays, at 51-75 persons/ha; on weekdays at less than 50 persons/ha. However, on special holidays, the tolerance of visitor density is 101-150 persons/ha. This indicates that visitors' expectations of the fact that holidays are more crowded makes them to tolerate a greater number of visitors. Thus on holidays the tolerance tends to coincide with high density.

ix. Cross-analysis of recreation activities and sites with perception of crowdedness (Appendix 8.3, Table 12).

Visitors at different recreation sites

while undertaking various activities have differing perception of crowdedness. Those activities at recreation spots engendering the highest proportion of perceptions of crowdedness of 51-75 persons/ha include landscape observation at inside Encore Garden, picnicking and barbecuing at the physical training field, and camping and the physical training at Chungcheng Camping Site. Recreational spots engendering the highest proportion of perceptions of crowdedness of 76-100 persons/ha include landscape observation at Encore Garden Gate and temple visiting at Sheng-shou Temple. Other spot and their perceived crowdedness (by the largest proportion of visitors), include picnicking and barbecuing at Chungcheng Camping Site, at less than 50 persons/ha; artificial amusement at Cartory Amusement Park, at more than 200 persons/ha; mountain climbing and hiking on the Mountain Climbing Footpath. This indicates that visitors' perceptions of crowdedness are very much affected by the particular recreation spot and type of activity. Among these, most of the perception of crowdedness is concentrated amid 51-100 persons/ha. However, perception of crowdedness in picnicking and barbecuing at Chungcheng Camping Site is the lowest, while the artificial amusement at Cartory stands at the highest.

x. Cross-analysis of each recreation activity and spots with the tolerance of visitor density (Appendix 8.3, Table 13).

For the various recreation activities and spots, visitor perception of tolerance differ. The following are the activities and spots and their relation to perception of tolerance as expressed by the highest proportion of visitors: camping at Chungcheng Camping Site, at 1-75 persons/ha; landscape observation inside Encore Garden and temple visiting at Sheng-shou Temple at 76-100 persons/ ha; landscape observation at Encore Garden Gate, at 101-150 persons/ha; physical training at the Physical Training Field, at 150-200 persons/ha; picnicking and barbecuing at Chungcheng Camping Site and Physical Training Field and artificial amusement at Cartory, at more than 200 persons/ha; and include mountain climbing on the Mountain Climbing Footpath, at 50 persons/km. However, the data indicate that activities at some spots have a larger range of visitors perception of tolerance. For example, landscape observation at Encore Garden Gate engenders a tolerance of 76-150 persons/ha, while landscape observation inside Encore Garden is 76-200 persons/ha; picnicking and barbecuing at Chungcheng Camping Site has two ranges; that is, more than 200 persons/ha and 51-100 persons/ha; picnicking and barbecuing at the Physical Training Field is 150-200 persons/ha, indicating that visitors' tolerance limit is higher there.

2. <u>Part II: Development Direction of Ta-keng Scenic Area</u>

One of the purposes of the study is to understand the potential development of Ta-keng Scenic Area. Through the questionnaire, the motives, desired outcome, satisfactions, reasons for dissatisfaction, willingness to revisit and the attitudes of the visitors who come to visit the area are all explored. The results are explained as follows:

(1) Analysis of Satisfaction Degree and Willingness to Revisit (Appendix 8.3, Table 14)

a. Visitor satisfaction : Those satisfied, account for 45.2%; somewhat satisfied, 36.2%; unsatisfied and very unsatisfied, total only 6.4%. This indicates that more than 80% of the visitors are at least somewhat satisfied.

b. Visitors willing to revisit account for 65.8%; those unwilling, account for 9.6%. This indicates that the recreational functions of Ta-keng Scenic Area are justified by most visitors.

(2) Motive, Outcome and the Reason for Unwilling to Revisit (Appendix 8.3, Table 15)

a. The main motive in coming to Ta-keng Scenic Area is to be close to nature, accounting for 75.2% of the visitors. The second motive is to experience of change of pace, accounting for 69.3%; the remainder is physical training (26.6%); to broaden knowledge (17.3%); and to increase social activity opportunities (11.8%). This indicates that main motives of most visitors are to be close to nature and to experience of change of pace.

b. It is obvious that visitors' greatest desired outcome is mainly for relaxation, accounting for 86.4%; the second is for mental satisfaction, 38.1%; natural beauty enjoyment, at 32%; to increase social activity opportunities, 11.4%; and to increase knowledge, 81%.

c. Reasons for being unwilling to revisit are distributed fairly evenly, but those who have not been satisfied with their visit are the most, accounting for 41.4%. Those citing too many people, accounts for 31.4%; lack of landscape characteristics, 30%; no time, 28.1%; inconvenient in transportation, 19.5%; and too much in a mess, 17.6%. This indicates that the future development of Ta-keng Scenic Area should stress landscape maintenance and proper management.

(3) <u>Analysis of Visitors' Satisfaction Degree, Number, Group Size and Willingness to Revisit</u> (Appendix 8.3, Table 16)

a. The tendency that the greater the number of visitors, the greater visitors' dissatisfaction will be, indicates that the satisfaction degree has a close relationship to the number of visitors.

b. The tendency that the greater the number of visitor groups, the greater visitors' dissatisfaction will be, indicates that the satisfaction degree has a close relationship to the numbers of groups.

c. Visitors willing to revisit tend to be satisfied with their visit; visitors uncertain about revisiting tend to be somewhat satisfied with their visit; visitors unwilling to revisit tend to be unsatisfied with their visit. This indicates that the satisfaction degree has a close relationship to whether a revisit is to be made.

(4) Analysis of Visitors' Attitudes to the Future Development of Ta-keng Scenic Area (Appendix 8.3, Table 17)

All visitors think that the future development of Ta-keng Scenic Area should emphasise natural landscape maintenance. Among these, visitors for physical training account for 81%; the remainder are mostly more than 70%, except those for artificial amusement (60.8%). This indicates that most visitors recognise the importance of conserving the natural environment.

8.2.4 Measurement of Social-Psychological Carrying Capacity

From the analysis made above, it is known that visitors' perception of crowdedness and perception of tolerance in relation to the various holidays, recreation sites and activities. In order to avoid the effects of the limit-value and analyser's subjectivity, this study sorted the questionnaire data according to different holidays, and further calculated the median value of each recreation activity at each recreation site, and visitors' perception of crowdedness and perception of tolerance for different holidays, so as to evaluate the social-psychological carrying capacity.

1. From the found median value of the cross-analysis data of each recreation activity, site and holiday with perception of crowdedness and perception of telerance (Tables 8.4, 8.5 and 8.6), it is known that when visitors

Table 8.4 Cross-analysis Data of Perception of Crowdedness of Each Recreation Activity and Spot on Different Holidays

I	Landscape observation						Picnicking & Barbecuing				Camping			Artificial Amusement			Physical Training			Temple Visiting			Mountain Climbing		
II	Encore Garden Gate			Inside of Encore Garden			Chung-cheng Camping site		Physical Training Field		Chung-cheng Camping Site			Cartory Amusement Park			Physical Training Field			Sheng-shou Temple			Mountain Climbing Footpath		
III IV	A	B	C	A	B	C	A	B	A	B	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
< 50 < 6	5 2.3	9 4.2	30 14.1	10 5.3	3 1.6	24 12.8	13 13.8	10 10.6	2 6.9	3 8.8	4 5.5		4 5.5	2 1.4	6 4.2	11 7.7	16 9.5	6 3.6	5 3.0		1 0.5	6 2.9	5 3.6	10 7.2	2 1.4
50-75 7-10	24 11.3	15 7.0	10 4.7	9 4.8	14 7.5	20 10.7	11 11.7	7 7.4	6 17.6	4 11.8		17 23.3	13 17.8	2 1.4	7 1.9	21 14.7	29 17.3	16 9.5	2 1.2	24 11.6	30 14.5	15 7.2	14 10.1	7 5.0	9 6.5
76-100 11-20	27 12.7	22 10.3	10 4.7	16 9.6	13 7.0	6 3.2	15 16.0	3 3.2	6 17.6	3 8.8		1 1.4	2 2.7	8 5.6	9 6.3	10 7.0	26 15.5	7 4.2	8 4.8	19 23.7	30 14.5	25 12.1	17 12.2	15 10.8	3 2.2
101-150 21-30	18 8.5	14 6.6	11 5.2	13 7.0	12 6.1	6 3.2	5 5.3	4 4.3	2 6.9	5 14.7		4 4.5		7 4.9	10 7.0	6 4.2	14 8.3	11 6.5	3 1.8	12 5.8	3 1.4	7 3.4	6 4.3	4 2.9	4 2.9
151-200 31-50	7 3.3		6 2.8	6 2.7	17 9.1	11 5.9	6 6.4	3 3.2	3 8.8			4 5.5	5 6.8	3 2.1	7 4.9	2 1.4	14 8.3	5 8.0	3 1.8	1 0.5	1 0.5	3 1.4	11 7.9	2 1.4	2 1.4
> 200 > 50	1 0.5		4 1.9	2 1.1	4 2.1	2 1.1	12 12.8	5 5.3			1 1.4	7 9.6	11 15.1	8 5.6	11 7.7	13 9.1	1 0.6	1 0.6	1 0.6				13 9.4	10 7.2	5 3.6
	82 38.5	60 28.2	71 33.3	55 29.1	63 33.7	69 36.9	62 66.0	32 34.0	19 55.9	15 14.1	6 6.8	33 45.2	35 47.9	30 21.0	50 35.0	63 44.1	100 59.5	46 27.4	22 13.1	86 41.5	65 31.4	56 27.1	66 47.5	48 34.5	25 18.0

I. Activities II. Recreation Spots III. Time Schedule

IV. Perception of Crowdedness (Person/ha) (Person/km)

A: Special holiday B: Routine holiday C: Weekday

Table 8.5 Cross-analysis Data of Perception of Tolerance of Each Recreation Activity and Spot on Different Holidays

I	Landscape observation						Picnicking & Barbecuing				Camping			Artificial Amusement			Physical Training			Temple Visiting			Mountain Climbing	
II	Encore Garden Gate			Inside of Encore Garden			Chung-cheng Camping site		Physical Training Field		Chung-cheng Camping Site			Cartory Amusement Park			Physical Training Field			Sheng-shou Temple			Mountain Climbing Footpath	
III IV	A	B	C	A	B	C	A	B	A	B	A	B	C	A	B	C	A	B	C	A	B	C	A	B
< 50 < 6	2 0.9		23 10.8	8 4.3		18 9.6	10 10.6	5 5.3	2 5.9	1 2.9	4 5.5	2 2.7	10 13.7		6 4.2	9 6.3	6 3.6		6 3.6			4 1.9	2 1.4	6 4.3
50-75 7-10	3 1.4	5 2.3	10 4.7	5 2.7	4 2.1	10 5.3	12 12.8	5 5.3	3 8.8			13 17.8	4 5.5	1 0.7	1 2.8	12 8.4	8 4.8		1 0.6	8 3.9	6 2.9	14 6.8	9 6.5	7 5.0
76-100 11-20	20 9.4	18 8.5	11 5.2	20 10.7	12 6.1	22 11.8	12 12.8	7 7.4	4 11.8	1 2.9		4 5.5	5 6.8		3 2.1	8 5.6	16 9.5	3 1.8	3 1.8	46 22.2	48 23.2	26 12.6	13 9.4	15 10.8
101-150 21-30	31 14.6	15 7.0	6 2.8	12 6.1	12 6.4	6 3.2	9 9.6	3 3.2	4 11.8	6 17.6		5 6.8	1 1.4	1 0.7	3 2.1	10 7.0	20 11.9	5 8.0	6 8.6	30 14.5	6 2.9	8 3.9	8 5.8	4 2.9
151-200 31-50	12 5.6	17 8.0	9 4.2	5 2.7	19 10.2	6 3.2	7 7.4	4 4.3	6 17.6	7 20.6		6 8.2	4 5.5	7 4.9	13 9.1	6 4.2	35 20.8	18 10.7	6 8.6	2 1.0	4 1.9	3 1.4	15 10.8	3 2.2
> 200 > 50	14 6.6	5 2.3	12 5.6	55 29.1	16 8.6	7 3.7	12 12.8	8 8.5			1 1.4	3 4.1	11 15.1	21 14.7	21 14.7	18 12.6	15 8.9	20 11.9			1 0.5	1 0.5	19 13.7	13 9.4
	82 38.5	60 28.2	71 33.3	55 29.1	63 33.7	69 36.9	62 66.0	32 34.0	19 55.9	15 14.1	6 6.8	33 45.2	35 47.9	30 21.0	50 35.0	63 44.1	100 59.5	46 27.4	22 13.1	86 41.5	65 31.4	56 27.1	66 47.5	48 34.5

I. Activities II. Spots III. Time Schedule IV. Perception of Crowdedness (person/ha) (person/km)

A: Special holiday B: Routine holiday C: Weekday

Table 8.6 Median Value of Each Recreation Activity on Different Holidays and Spots with Perception of Crowdedness and Perception of Tolerance

		Special Holiday	Routine Holiday	Weekday
Perception of Crowdedness	landscape observation. Encore Garden Gate	87.1	82.2	64.8
	landscape observation. Inside of Encore Garden	89.3	107.3	64.1
	picnicking & barbecuing. Chungcheng Camping site	87.7	110.3	
	picnicking & barbecuing. Physical Training Field	82.3	80.2	
	camping. Chungcheng Camping Site	40.0	73.8	87.5
	artificial amusement. Cartory Amusement Park	122.4	116	75.4
	physical training. Physical Training Field	80.8	79.6	88.5
	temple visiting. Sheng-shou Temple	85.7	77.3	83.0
	mountain climbing. Mountain Climbing Footpath	19.2	15.7	12.5
Perception of Tolerance	landscape observation. Encore Garden Gate	113.9	124.3	81.7
	landscape observation. Inside of Encore Garden	124.8	160.2	83.4
	picnicking & barbecuing. Chungcheng Camping site	94.8	97.4	
	picnicking & barbecuing. Physical Training Field	157.3	155.2	
	camping. Chungcheng Camping Site	40.0	85.4	93.5
	artificial amusement. Cartory Amusement Park	215.3	185.6	113.5
	physical training. Physical Training Field	150.0	192.7	167.7
	temple visiting. Sheng-shou Temple	95.0	89.8	85.6
	mountain climbing. Mountain Climbing Footpath	32.3	18.3	16

undertake recreation activities on holidays, both their perception of crowdedness and perception of tolerance are generally higher than those on weekdays. These values on special holidays are even higher than those on routine holidays, thus indicating that visitors undertaking activities on holidays exhibit greater psychological capacity to tolerate a larger number of visitors. Thus the social-psychological carrying capacity on holidays is also higher. On the other land, the carrying capacity tends to be lower on weekdays. This means that since visitors' expectations of the wilderness experience and solitude are higher on weekdays, then the social-psychological carrying capacity is lower.

2. Analysis of perception of crowdedness and perception of tolerance in terms of different activities and spots.

From Table 8.7, it is known that for the various activities at different spots, the perception of tolerance is higher than the perception of crowdedness, except for camping and barbecuing at Chungcheng Camping Site. Physical training has the highest (205%). Others in order are picnicking and barbecuing at the Physical Training Field (192%), artificial amusement at Cartory Amusement Park (164%), landscape observation inside Encore Garden (141%), temple visiting at Sheng-shou Temple (110%), mountain climbing and hiking on the Mountain Climbing Footpath (140%), landscape observation at Encore Garden Gate (136%) and camping at Chung-cheng Camping Site (109%). This

Table 8.7 Comparison of Each Recreation Activity and Spot with Perception of Crowdedness

	Median Value of Perception of Crowdedness (per./ha or per./km)	Median Value of Perception of Tolerance (per./ha or per./km)	Ratio of Perception of Tolerance to Perception of Crowdedness(%)
landscape observation. Encore Garden Gate	78.2	106.6	136
landscape observation. Inside of Encore Garden	86.9	122.8	141
picnicking & barbecuing. Chungcheng Camping site	99.0	96.1	97
picnicking & barbecuing. Physical Training Field	81.3	156.3	192
camping Chungcheng. Camping Site	67.1	73.0	109
artificial amusement. Cartory Amusement Park	104.6	171.5	164
physical training. Physical Training Field	83.0	170.1	205
temple visiting. Sheng-shou Temple	82.0	90.0	110
mountain climbing. Mountain Climbing Footpath	15.8	22.2	140

indicates that visitors' social-psychological carrying capacity tolerability tends to be higher when undertaking the more dynamic activities; otherwise it is lower.

3. Analysis of perception of crowdedness and perception of tolerance in terms of different holidays, activities and spots.

Because visitors' perception of crowdedness and perception of tolerance are different for different holidays, activities and spots, this study, depending on the proportion of the number of questionnaires used for investigation on different holidays, adds weight to the measurement of the social-psychological carrying capacity. The ratio is shown in Table 8.8. The median values of perception of crowdedness and perception of tolerance of each recreation activity and spot in terms of different holidays, after being weighted, are shown in Table 8.9.

4. Combined Results.

From the above analysis results, it is known that the weighted values of the perception of crowdedness and perception of tolerance for different recreation activities, at different spots and on different holidays are obviously different. In terms of the perception of crowdedness, the artificial amusement at Cartory has the highest (100 persons/ha), the next being picnicking and barbecuing at Chungcheng Camping Site (95.4 persons/ha). The lower values include camping and barbecuing at

Table 8.8 Interviewee' Ratio of Each Recreation Activity and Spot in terms of Different Holidays

	Special Holiday		Routine Holiday		Weekday		Total	
landscape observation. Encore Garden Gate	82	38.5%	60	28.2%	71	33.3%	213	100%
landscape observation. Inside of Encore Garden	55	29.4%	63	33.7%	69	36.9%	187	100%
picnicking & barbecuing Chungcheng. Camping site	62	66.0%	32	34.0%	0	%	94	100%
picnicking & barbecuing. Physical Training Field	19	55.9%	15	44.1%	0	%	34	100%
camping. Chungcheng Camping Site	5	6.8%	33	45.2%	35	47.9%	73	100%
artificial amusement. Cartory Amusement Park	30	21.0%	50	35.0%	63	44.1%	143	100%
physical training. Physical Training Field	100	59.5%	46	27.4%	22	13.1%	168	100%
temple visiting. Sheng-shou Temple	86	41.5%	65	31.4%	56	22.1%	207	100%
mountain climbing. Mountain Climbing Footpath	66	47.5%	48	34.5%	25	18.05	139	100%

Table 8.9 Weighted-Value of Perception of Crowdedness and Perception of Tolerance in terms of Each Recreation Activity Spot and Holiday

		Speical holiday	Routine holiday	Weekday	Total
Perception of Crowdedness	landscape observation. Encore Garden Gate	33.5	23.4	21.6	78.5
	landscape observation. Inside of Encore Garden	26.3	36.1	23.7	86.1
	picnicking & barbecuing. Chungcheng Camping site	57.9	37.5		95.4
	picnicking & barbecuing. Physical Training Field	46	35.4		81.4
	camping. Chungcheng Camping Site	2.7	33.4	41.9	78
	artificial amusement. Cartory Amusement Park	25.7	40.6	33.3	99.6
	physical training. Physical Training Field	48.1	21.8	11.6	81.5
	temple visiting. Sheng-shou Temple	35.6	24.3	22.5	82.4
	mountain climbing. Mountain Climbing Footpath	9.12	5.4	2.3	16.8
Perception of Toleranceene	landscape observation. Encore Garden Gate	43.9	35.1	27.2	106.2
	landscape observation. Inside of Encore Garden	36.7	30.8	23.7	91.2
	picnicking & barbecuing. Chungcheng Camping site	62.6	33.0		95.6
	picnicking & barbecuing. Physical Training Field	87.9	19.9		107.8
	camping. Chungcheng Camping Site	2.7	29.3	44.8	76.8
	artificial amusement. Cartory Amusement Park	45.2	65.0	50.1	160.3
	physical training. Physical Training Field	89.3	52.8	22.0	164.1
	temple visiting. Sheng-shou Temple	39.4	28.2	23.2	90.8
	mountain climbing. Mountain Climbing Footpath	15.3	6.3	2.9	24.5

Chungcheng Camping Site (78 persons/ha) and landscape observation at Encore Garden Gate (79 persons/ha). However, mountain climbing is much lower at 17 persons/km. In terms of perception of tolerance, artificial amusement at Cartory has the highest value (160 persons/ha); physical training at the Physical Training Field is a little higher (164 persons/ha); camping at Chungcheng Camping Site is lower (77 persons/ha).

To determine the social-psychological carrying capacity with more representativeness and exactness, this study has employed the mean value of the weighted values of the perception of crowdedness and perception of tolerance as the basis and the measured range of the original carrying capacity to find out the carrying capacity of each recreation activity and site (Table 8.10).

8.3 Physical-Ecological Carrying Capacity

8.3.1 Survey Method Selection

As concluded in section 4.5 of Chapter Four, different survey methods for determining recreation carrying capacity have different suitabilities. This study adopted a method possessing more precision, but it has a more complicated operation process: the Analytic Hierarchy Process (AHP). The theory of this method are described in Chapter Four. No further discussion is made here.

Table 8.10 Social-Psychological Carrying Capacity of Each Recreation Activity at Each Recreation Spot

Activities Spots	Weighted-values of Perception of Crowdedness (per./ha or per./km)	Weighted-values of Perception of Tolerance (per./ha or per./km)	Mean Values (per./ha or per./km)	Range-values of Social-phychological Carrying Capacity (per./ha or per./km)
landscape observation. Encore Garden Gate	78.5	106.2	92.4	66-91
landscape observation. Inside of Encore Garden	86.1	91.2	88.7	74-99
picnicking & barbecuing. Chungcheng Camping site	95.4	95.6	95.5	83-108
picnicking & barbecuing. Physical Training Field	81.4	107.8	94.6	82-103
camping. Chungcheng Camping Site	78	76.8	77.4	65-90
artificial amusement. Cartory Amusement Park	99.6	160.3	30.0	118-143
physical training. Physical Training Field	84.5	164.1	122.8	110-135
temple visiting. Sheng-shou Temple	82.4	90.8	86.6	74-99
mountain climbing. Mountain Climbing Footpath	16.8	24.5	20.7	16-26

8.3.2 Factors in the Selection of the Analytic Hierarchy Process

The AHP method employs a questionnaire based on professionals' relatively weighted judgement of the factors which affect the physical-ecological carrying capacity. From the judgement results, an analyse is made of the degree of the affect of the recreational activities on the ecological environment of the recreation site. Then in accordance with the visitor density which is acceptable to the professionals in the questionnaire, calculation of the physical-ecological carrying capacity of each site is made. Therefore, the factors that affect the environment and the subscriteria have to be considered.

1. Factors Considered.

In the study, concerning the selection of the affecting factors of the recreational activity on the environment of each site in Ta-keng Scenic Area, the following four factors must be considered

(1) Traits of the recreation resources of Ta-keng Scenic Area.

(2) Planning and management goals and the problems intended to be solved.

(3) Understanding of the possible effects of recreational behaviour made on the environment.

(4) Past literature regarding recreation activities which affect the environment.

2. Affecting Factors and Subcriteria.

Factors which affect the environment and the subcriteria of the study area are shown in Table 8.11.

Table 8.11 Physical-Ecological Affecting Factors and Subcriteria

Affecting Factors on the Recreation Site	Subcriteria
1. Effects on plants	(1) Uniqueness of the plant species. (2) Number and density of the plants (3) The pristine wilderness of the plant population
2. Effects on animals	(1) Uniqueness of animal species (2) Number and density of animals (3) Types of animals (4) Species diversity of animals
3. Effect on Water resources	(1) Distance of water source from the site (2) Quantity of potable water (3) Collection and treatment of polluted water (4) Drainage conditions
4. Effect on the natural landscape	(1) Effects on the pristine wilderness of the natural landscape (2) Effects on the continuity of the natural landscape (3) Effects on the uniformity of the natural landscape (4) Effects on the variablity of the natural landscape (5) Effects on the contents of the natural landscape (6) Effects on the visual amenity of the natural landscape
5. Effects derived from the wastes of the site sanitation	(1) Size of the site area (2) Status of the waste treatment installations (3) Access to site waste treatment installations
6. Effects on special interests	(1) Effects on site local character (2) Effects on the regional landmark (3) Effects on the site's regional character
7. Effects on terrain	(1) Effects on the pristine wilderness of the topography (2) Effects on topographical variation (3) Effects on topographical continuity
8. Effects on geology	(1) Effects on geological stability (2) Effects on soil erosion (3) Effects on water percolation (4) Effects on wastes and land reclamation on the geology

The definitions and meaning of the affecting factors and subcriteria presented above are explained in Appendix 8.5.

8.3.3 Questionnaire Design and Implementation of the Analytic Hierarchy Process

The study uses the Analytic Hierarchy Process (AHP) to analyse the effects of recreation activities on environmental factors; to compare the tolerance of the subcriteria characteristics of each site (ie. both the recreation sites and preservation area); to analyse the effects of recreation activities on the site's physical environment; and to analyse the limits of acceptable change of the physical environment which is affected by the activities at each site. Therefore, there are two parts to the questionnaire:

1. Measure the degree that the recreation acitvities impinge upon the ecological factors and the subcriteria.

2. Measure the momentary capacity of recreational activities at each site under the tolerance of the ecological factors.

The study included visits to 20 professionals and scholars who had extensive knowledge of the recreation resources of Ta-keng Scenic Area. They are divided into nine groups according to their specialities:(1) 3 botanists (2) 2 zoologists (3) 1 culture and antiquity expert (4) 2 water resource pollution experts (5) 3 landscape and recreation experts (6) 2 geologists (7) 2 geographers (8) 3 management experts and (9) 2 environment planners. A printed questionnaire is shown in Appendix 8.6.

8.3.4 <u>Measurement of Physical-Ecological Carrying Capacity</u>

The affecting degree of the recreation activities made upon the recreation site varies for the nature of activity and the physical environment are different. The physical-ecological carrying capacity in this study adopted the concept of limit of acceptable change. That is, based on the questionnaire made by the professionals and the scholars, to find out the relative weight of each of the physical-ecological affecting factors and the subcriteria (parts A and B of the questionaire). After examining the ecological status on each site, analysing the total affecting degree of the recreation activities made upon the site, considering the "visitor's density of every recreation site of Ta-keng Scenic Area" which is acceptable by the professionals and the scholars, and by using the revised BOR method, the physical ecological carrying capacity is calculated. The steps are as follow:

1. Analysing the relative weight of each of the physical ecological affecting factors and the subcriteria of each recreation site. (Appendix 8.7)

2. Classifying the affecting degree of each subcriteria made to the physical ecological affecting factors for each

recreation site into five classes: those with the least affecting degree are taken as the first class, the rest in order are as the second, the third, the fourth and the fifth. Each of them is marked, that is, 1 for the first class, 0.75 for the second, 0.5 for the third, 0.25 for the fourth and 0 for the fifth.

3. With the marks of each site multiplied by the relative weight of the subcriteria the total number is the affecting value of all activities made to the physical ecological environment of every site.

4. With this result matching with the limit of acceptable change, through the revised BOR method, visitor's density (i.e. the maximum momentary visitor's allowable capacity) of every site is measured.

5. The density (m^2/person or person/m^2) obtained through the above procedure is the physical-ecological carrying capacity of each recreation site.

8.3.5 <u>Analytic Results of the Analytic Hierarchy Process</u>

1. Total relative weight of the physical ecological affecting factors.

Through the calculation in Appendix 8.7, the total relative weight of the physical ecological affecting factors in this study (all by professionals and scholars) are listed in Table 8.12.

Table 8.12 <u>Total Relative Weight of Affecting Factors of Each Recreation Spot</u>

Activity, spot / Affecting Factor	landscape observation Artificial Area of Encore	landscape observation Wild Area of Encore	landscape observation Preservation Area	camping & barbecuing Chungcheng Camping Site	camping Chungcheng Camping Site	physical training Physical Training Field	temple visiting Sheng Shou Temple	mountain climbing Mountain Climbing Footpath
1. Effects on the flora of the site	0.109155	0.177228	0.171634	0.210433	0.245528	0.218849	0.110937	0.257732
2. Effects on the fauna of the site	0.109713	0.090580	0.101888	0.082416	0.110648	0.133499	0.099806	0.157825
3. Effects on the water resource of the site	0.083881	0.072658	0.115504	0.135093	0.187541	0.104683	0.156617	0.120056
4. Effects on the natural landscape of the site	0.195737	0.157897	0.136490	0.166601	0.142181	0.186275	--	0.245327
5. Effects of wastes of the site on the environ. sanitation	0.169118	0.225631	0.219404	0.405457	0.314102	--	--	--
6. Effects on the special interests of the site	0.094022	0.136234	0.110382	--	--	--	0.262732	--
7. Effects on the topography of the site	0.125269	0.032469	0.069370	--	--	0.193182	--	0.122058
8. Effects on the geology of the site	0.113104	0.067304	0.075328	--	--	0.163500	--	0.097002

2. Total relative weight of the physical ecological subcriteria.

In this study, the order of the relative weight of subcriteria made by every kind of professionals and scholars is similar to the results (Table 8.13 for example) made by all professionals and scholars as a whole. Therefore, with all the professionals' and scholars' subcriteria relative weight multiplied by the affecting factor weight which belongs to that subcriterion, the result is the relative weight for all subcriteria as shown in Table 8.14.

Table 8.14 Total Relative Weight of Subcriteria of Each Recreation site

Subcriteria	Relative Weight	Order	Subcriteria	Relative Weight	Order
Uniqueness(flora)	0.055948	3	Contents	0.032104	12
Quantity & Density (flora)	0.26492	20	Visual Amenity	0.025333	21
Pristine Wilderness	0.26716	19	Size	0.022458	25
Uniqueness(flora)	0.014529	29	Treatment	0.060199	2
Quantity & Density (fauna)	0.035457	9	Accessbility	0.086540	1
Type & Species (fauna)	0.028072	17	Local Charac-teristics	0.023530	23
The No. of Species (fauna)	0.031655	14	Regional Landmarks	0.020882	26
Distance	0.015398	28	Speciality	0.049610	4
Quantity	0.013231	30	Pristine Wilderness	0.041840	7
Treatment	0.023150	24	Variety	0.035101	10
Drainage	0.032103	13	Continuity	0.048329	5
Pristine Wilderness	0.045441	6	Stability	0.027360	18
Continuity	0.018970	27	Soil Erosion	0.024887	22
Uniformity	0.032543	11	Percolation	0.030253	16
Variability	0.041345	8	Earth Filling	0.030604	15

Table 8.13 Relative Weight of Subcriteria (landscape observation, Artificial Area of Encore)

Affecting Facotrs	Subcriteria	Various Experts	Total Experts
Effects on the flora of the site	Uniqueness Quantity & Density Pristine Wilderness	0.494037 0.317593 0.188370	0.439011 0.290768 0.270222
Effects on the funa of the site	Uniqueness Quantity & Density Type & Species The No. of Species	0.152614 0.246506 0.192975 0.407905	0.146238 0.273803 0.257717 0.322242
Effects on the water resource of the site	Distance Quantity Treatment Drainage	0.067113 0.167633 0.317321 0.447933	0.147525 0.169528 0.282306 0.400641
Effects on the natural landscape of the site	Pristine wilderness Continuity Uniformity Variability Contents Visual Amenity	0.248161 0.061719 0.073586 0.345831 0.163205 0.107498	0.200054 0.099866 0.147668 0.236208 0.168197 0.148007
Effects of the wastes of the site on the environ. sanitation	Site Treatment Accessbility	0.107132 0.341099 0.551769	0.137268 0.326601 0.536130
Effects of the special interests of the site	Uniqueness Quantity & Density Speciality	0.385380 0.111889 4.502731 4.502731	0.248184 0.238175 0.513641 0.513641
Effects on the topography of the site	Pristine Wilderness Variability Continuity	0.479347 0.136995 0.383659	0.363210 0.289336 0.347454
Effects on the geology of the site	Uniqueness Soil Erosion Percolation Earth Filling	0.280959 0.192666 0.279794 0.246581	0.205465 0.211047 0.249894 0.333593

3. Total affect value

With the affecting degree of each activity to the subcriteria of the present physical ecological status on every spot (Table 8.15) multiplied by the above total relative weight respectively, and added them together, the whole sum is the total affect value (Table 8.16).

4. Limit of Acceptable Change (Visitors' Density)

From part C of the questionaire, it is known that "the professionals' acceptable visitors' density of every recreation spot in Ta-keng Scenic Area" is as in the following Table 8.17.

8.3.6 Measurement of Physical-Ecological Carrying Capacity

In order to avoid the extreme value and to balance every participant's subjective recognition, this study further made use of the revised BOR method to measure the physical-ecological carrying capacity of each recreation spot as is shown in the Table 8.18. The steps of calculation are shown in Appendix 8.8.

Table 8.18 Physical-Ecological Carrying Capacity of Each Recreation and Spot

Activity, spot	PECC (person/m^2)	Activity, spot	PECC (person/m^2)
landscape observation Wild Area of Encore	0.0044	camping Chungcheng Camping Site	0.0127
landscape observation Artificial Area of Encore	0.0189	physical training Physical Training Field	0.0181
landscape observation Preservation Area	0.0014	temple visiting Sheng-Shou Temple	0.0138
picnicking & barbecuing Chungcheng Camping Site	0.0173	mountain climbing Mountain Climbing Footpath	0.0026

Table 8.15 Affecting Degree of Recreation Activity on Subcriteria of Each Recreation Spot

Recreation Activities	Recreation Spots	Effects on the flora of the site			Effects on the fauna of the site				Effects on the water resource of the site				Effects on the natural landscape of the site						Effects of wastes of the site on the Environment		
		1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2	5.3
landscape observation	Wild Area of Encore	2	1	3	4	5	4	5	3	4	5	3	4	2	4	1	3	3	3	2	2
landscape observation	Artificial Area of Encore	2	4	5	1	1	1	1	1	3	5	1	5	5	5	1	3	5	4	1	1
landscape observation	Preserva-tion Area	1	1	1	5	5	6	5	5	5	1	5	1	1	1	2	1	1	1	4	4
picnicking & barbecuing	Chungcheng Camping Site	3	3	2	3	3	3	3	1	2	4	4	3	3	3	4	4	4	2	3	3
camping	Chungcheng Camping Site	3	3	2	3	3	3	3	1	2	4	4	3	3	3	4	4	4	2	3	3
physical training	Physical Training Field	4	3	2	4	4	3	3	2	1	3	3	2	4	3	5	5	2	-	-	-
temple visiting	Sheng shou Temple	5	5	4	2	2	2	2	4	4	5	2	-	-	-	-	-	-	-	-	-
mountain climbing	Mountain Climbing Footpath	1	1	1	5	5	5	4	5	5	2	5	1	1	2	3	2	1	-	-	-

Table 8.15 Affecting Degree of Recreation Activity on Subcriteria of Each Recreation Spot (Contd.)

Recreation Activities	Recreation Spots	Effects on the Special Interests of the site			Effects on the geology of the site				Effects on the topography of the site			Effects on the culture & relics of the site		
		6.1	6.2	6.3	7.1	7.2	7.3	7.4	8.1	8.2	8.3	9.1	9.2	9.3
landscape observation	Wild Area of Encore	3	2	3	3	2	3	4	4	4	3	-	-	-
landscape observation	Artificial Area of Encore	4	1	1	4	3	5	5	5	5	4	-	-	-
landscape observation	Preserva-tion Area	1	3	1	1	1	1	1	1	1	1	-	-	-
picnicking & barbecuing	Chungcheng Camping Site	-	-	-	-	-	-	-	-	-	-	-	-	-
camping	Chungcheng Camping Site	-	-	-	-	-	-	-	-	-	-	-	-	-
physical training	Physical Training Field	-	-	-	3	4	4	3	3	3	3	-	-	-
temple visiting	Sheng-shou Temple	2	2	2	-	-	-	-	-	-	-	3	2	4
mountain climbing	Mountain Climbing Footpath	-	-	-	2	2	2	2	2	2	1	-	-	-

Note:

1.1 Uniqueness : 1. rare 2. a little 3. many
1.2 Quantity & Density : 1. low 2. medium 3. high
1.3 Pristine Wilderness : 1. nature
2.1 Uniqueness : 1. rare 2. a little 3. many
2.2 Quantity & Density : 1. low 2. medium 3. high
2.3 Type & Species : 1. others 2. small 3. small and large
2.4 The No. of Species : 1. a little 2. many 3. various
3.1 Distance : 1. > 200m 2. 50-200m 3. < 50m
3.2 Quantity : 1. many 2. a little 3. rare
3.3 Treatment : 1. good 2. fair 3. poor
3.4 Drainage : 1. good 2. fair 3. poor
4.1 Pristine Wilderness : 1. good 2. fair 3. poor
4.2 Continuity : 1. good 2. fair 3. poor
4.3 Uniformity : 1. good 2. fair 3. poor
4.4 Variability : 1. good 2. fair 3. poor
4.5 Contents : 1. good 2. fair 3. poor
4.6 Visual Amenity : 1. good 2. fair 3. poor
5.1 Size : 1. > 30ha 2. 30-10ha 3. < 10ha
5.2 Treatment : 1. good 2. fair 3. poor
5.3 Access : 1. < 20m 2. 20-50m 3. > 50m
6.1 Local Characteristics : 1. special 2. popular 3. none
6.2 Regional Landmark : 1. special 2. popular 3. none
6.3 Speciality : 1. special 2. popular 3. none
7.1 Stability : 1. good 2. fair 3. poor
7.2 Soil Erosion : 1. good 2. fair 3. poor
7.3 Percolation : 1. good 2. fair 3. poor
7.4 Earth Filling : 1. good 2. fair 3. poor
8.1 Pristine Wilderness : 1. good 2. fair 3. poor
8.2 Variety : 1. good 2. fair 3. poor
8.3 Continuity : 1. good 2. fair 3. poor
9.1 Cultural Characteristics : 1. special 2. popular 3. none
9.2 Man-made Landscape : 1. special 2. popular 3. none
9.3 Land Use : 1. good 2. fair 3. poor

Table 8.16 Total Effect Value of Physical Environment of Each Activity and Spot

Activity	Spot	Total Effect Value
landscape observation	Wild Area of Encore	0.4596159
landscape observation	Artificial Area of Encore	0.3782465
landscape observation	Preservation Area	0.8048617
picnicking & barbecuing	Chungcheng Camping Site	0.4331104
camping	Chungcheng Camping Site	0.4179109
physical training	Physical Training Field	0.4584197
temple visiting	Sheng Shou Temple	0.4827529
mountain climbing	Mountain Climbing Footpath	0.8347352

Table 8.17 The Acceptable Tourists Density of Experts

Activities, Spot	A	B	C	D	E	F	G	H
Density (m^2/person m /person)	10-100	50-410	200-900	10-130	20-200	20-120	10-120	10-100
Meam Value (m^2/person m /person)	58.5	231.5	562.5	62	91.75	57.75	67	54.5
Median Value (m^2/person m /person)	65	240	575	63.33	86.67	57.50	73.33	57.5
Decile (m^2/person m /person)	96 15	374 86	830 270	118 22	182 38	90 30	109 21	91 19

A = landscape observation, Artificial Area of Encore.

B = landscape observation, Wild Area of Encore.

C = landscape observation, Preservation Area.

D = Picnicking & barbecuing, Chungcheng Camping Site.

E = camping, Chungcheng Camping Site.

F = physical training, Physical Training Field.

G = temple visiting, Sheng-Shou Temple.

H = mountain climbing, Mountain Climbing Footpath.

8.4 Social-Psychological and Physical-Ecological Carrying Capacities of Each Subzone of Ta-keng Scenic Area

Based on the social-psychological and physical-ecological carrying capacities obtained from the analysis and measurement for each recreation site available in the Scenic Area and in reference to the information concerned. (4)(5)(6)(7)(8)(9) The social-psychological and physical-ecological carrying capacities of each subzone of Ta-keng Scenic Area are shown as in the Table 8.19.

Table 8.19 Social-Psychological and Physical-Ecological Carrying Capacity of Each Subzone of Ta-keng Scenic Area

No.of Subzone	X1,1	X1,2	X1,3	X1,4	X1,5	X2,1
PCC(person/m²)	0.0009	0.0063	0.0077	0.0050	0.0030	0.0011
Range(Decile) (person/m²)	0.0005 – 0.0015	0.0050 – 0.0075	0.0065 – 0.0090	0.0038 – 0.0063	0.0010 – 0.0020	0.0005 – 0.0015
PECC(person/m²)	0.0014	0.0181	0.0127	0.0173	0.0026	0.0014
Range(Decile) (person/m²)	0.0013 – 0.0015	0.0163 – 0.0201	0.0111 – 0.0145	0.0149 – 0.0202	0.0024 – 0.0028	0.0013 – 0.0015

No.of Subzone	X2,2	X2,3	X2,4	X2,5	X3,1	X3,2
SPCC(person/m²)	0.0123	0.0063	0.0095	0.0040	0.0031	0.0170
Range(Decile) (person/m²)	0.0110 – 0.0135	0.0050 – 0.0075	0.0082 – 0.0107	0.0016 – 0.0026	0.0025 – 0.0041	0.0168 – 0.0183
PECC(person/m²)	0.0181	0.0127	0.0173	0.0026	0.0044	0.0181
Range(Decile) (person/m²)	0.0163 – 0.0201	0.0111 – 0.0145	0.0149 – 0.0202	0.0024 – 0.0028	0.0039 – 0.0051	0.0163 – 0.0201

No.of Subzone	X3,4	X3,5	X3,6	X3,7	X3,8	X4,1
SPCC(person/m²)	0.0095	0.0100	0.0089	0.0067	0.0063	0.0012
Range(Decile) (person/m²)	0.0082 – 0.0107	0.0040 – 0.0060	0.0074 – 0.0099	0.0055 – 0.0080	0.0050 – 0.0075	0.0010 – 0.0014
PECC(person/m²)	0.0173	0.0026	0.0189	0.0150	0.0015	0.0044
Range(Decile) (person/m²)	0.0149 – 0.0202	0.0024 – 0.0028	0.0159 – 0.0234	0.0063 – 0.0074	0.0010 – 0.0020	0.0039 – 0.0051

No.of Subzone	X4,5	X5,1	X7,4	X7,6	X7,8	X7,13
SPCC(person/m²)	0.0040	0.0037	0.0170	0.0079	0.0123	0.0130
Range(Decile) (person/m²)	0.0016 – 0.0026	0.0033 – 0.0042	0.0157 – 0.0182	0.0066 – 0.0091	0.0110 – 0.0135	0.0118 – 0.0143
PECC(person/m²)	0.0036	0.0044	0.0173	0.0189	0.0015	0.0187
Range(Decile) (person/m²)	0.0012 – 0.0014	0.0039 – 0.0051	0.0149 – 0.0234	0.0159 – 0.0202	0.0010 – 0.0020	0.0159 – 0.0234

No.of Subzone	X7,14	X7,15	X8,16	X8,17
SPCC(person/m²)	0.0250	0.0125	0.0087	0.0125
Range(Decile) (person/m²)	0.0225 – 0.0275	0.0112 – 0.0137	0.0074 – 0.0099	0.0112 – 0.0137
PECC(person/m²)	0.0189	0.0189	0.0138	0.0138
Range(Decile) (person/m²)	0.0159 – 0.0234	0.0159 – 0.0234	0.0126 – 0.0164	0.0126 – 0.0164

REFERENCES

1. Young, K.S., et al., : "Social and Behavioural Study Methodology". (Volumes I, II). (in Chinese) Tung Hwa Book Co., Taipei, ROC, 1988, pp.406-438.

2. Ibid. 1, pp.75-86.

3. Ibid. 1, pp.131-158.

4. Wang, Hsiao Lin and Yu Feng Ho : "A Study on Ta-Keng Tourism Farm Village Planning". (in Chinese), A Report to Taichung City Government, Taichung, Taiwan, ROC, 1989, p. 133.

5. Wu, Yi Loon, et al., : "A Study on the Measurement of Recreation Carrying Capacity for the Camping Sites of Yu-Shan National Park". (in Chinese), Unpub. MSc. thesis, Chung Hsing Univ. Taipei, ROC, 1987, p. 111.

6. Taiwan, Urban and Housing Development Department, Council for Economic Planning and Development, Executive Yuan, : "A study on the sightseeing System of Taiwan". A Government Report, Taipei, ROC, 1983, p. 136.

7. Yu, Hwe Tseng : "A Study on the Development of Tourism and Recreation Area in Taiwan". (in Chinese), Unpub. MSc. thesis, Chung Shing Univ. Taipei, ROC, 1985, p. 94.

8. The Department of Urban Planning, Feng Chia Uinvsity : "A Study on the Recreation System of Taiwan". (in Chinese), A Report to the Tourism Bureau, Taiwan, ROC, 1988, p.112.

9. Taichung Shen Government : "The Comprehensive Plan of Houli Horse Riding Field and Its Surrounding Area". (in Chinese), A Report of Taichung Shen Government", Taichung Taiwan, ROC, 1988, pp. 55-76.

CHAPTER 9

FORMULATION AND EVALUATION OF LAND USE PLAN

9.1 Introduction

The ultimate purpose of modelling is to obtain an ideal output, that is, a set of feasible solutions which satisfies the supply and demand balance. From these feasible solutions through the decision maker's monitoring process, the best solution is obtained. This is the final result of recreation resources management.

Based on the discussion in Chapter Six, the recommended method in this study considers the three major factors--ecological, sociological and economic that simultaneously greatly affect recreation resources management. After inputing data into the model established in this study, operating on a personal computer via VIG package and through repeated PARETO RACE, decision makers can obtain the satisfactory solution which satisfies both the objective and constraints. This chapter discusses the modelling and its result.

Accomplishment of a recreation resources management plan can not be simply attained. Priority for the development of each zone should be given in accordance with planning objective, relationship between the functions of all facilities, development effort and construction budgets to ascertain rational use of resources and the quality of the development. Estimate of costs is the basic requirement in fulfiling the development plan and is one of the important parameters in the model established in this study. In this chapter, a phasing plan, a cash flow schedule and a net present value (N.P.V.) are to be discussed. The rough estimate of construction is based on the standard of the commodities price in central Taiwan, in October of 1989.

9.2 Phasing plan

9.2.1 Planning Concept

Ta-keng Scenic Area is large in area and has numerous and complicated development items. In order to achieve the planning objectives, lands within the area must be managerially analysed according to the special nature of the resources and the concept for future development, order of development priority and other concerned factors, to formulate the most proper phasing model as the basis for future development.

The phasing plan needs to reflect the planning objectives and order of development priority. Planners must formulate several alternative plans through economic studies and feasibility analyses, while policy makers determine the most feasible plan based on financial capability and degree of necessity, and then choose the best time to set up each of the public facilities.

9.2.2 Planning Principles

The order of development priorities in the phasing plan must be based on the following factors, all of which must be implemented first:

(1) Local public installations and facilities;

(2) Key issues within the overall public installations and facilities;

(3) Those areas for landscape and environment maintenance which are urgently needed;

(4) Governmental and local plans which have been sanctioned;

(5) Construction that either requires only small investment or those for which financial sources are more easily acquired;

(6) Construction undertakings that induce private investment;

(7) Areas with high economic value and rich resources;

(8) Artificial development areas and urban development areas that have greater potentials;

(9) Recreation spots that have already been developed and which have good operation conditions;

(10) Under the overall development objectives those that have greater returns to investment.

9.2.3 Development Phasing Plan

According to the phasing schedule, the plan for Ta-keng Scenic Area can be divided into five development periods, one year for each period. Thus it needs five years to complete the plan for the Area. (Table 9.1)

Table 9.1 Phasing of Ta-keng Scenic Area Development

Zones	Sub-zones	Items	Year				
			1	2	3	4	5
X1	X1,1	Preservation Area					**
	X1,2	Physical Training Field	**	**			
	X1,3	Camping Site		**	**		
	X1,4	Picnicking & Barbecuing Site		**	**		
	X1,5	Mountain Climbing Footpath	**	**	**	**	**
X2	X2,1	Preservation Area				**	**
	X2,2	Physical Training Field	**	**			
	X2,3	Camping Site		**	**		
	X2,4	Picnicking & Barbecuing Site		**	**		
	X2,5	Mountain Climbing Footpath	**	**	**	**	**
X3	X3,1	Preservation Area					**
	X3,2	Physical Training Field	**	**			
	X3,4	Picnicking & Barbecuing Site		**	**		
	X3,5	Mountain Climbing Footpath	**	**	**	**	**
	X3,6	Tourist Orchard Area				**	
	X3,7	Horse Riding Field	**	**	**	**	
	X3,8	Grass Skiing Field	**	**			
X4	X4,1	Forestry Preservation Area				**	**
	X4,5	Mountain Climbing Footpath			**	**	**
X5	X5,1	Farmscape Preservation Area			**	**	**
X7	X7,4	Picnicking & Barbecuing Site	**				
	X7,6	Tourist Orchard Area			**		
	X7,8	Grass Skiing Field		**	**		
	X7,13	Mechanical Play Equipment Area	**	**			
	X7,14	Tourist Centre Area	**	**			
	X7,15	Garden			**		
X8	X8,16	Relics & Temples Area	**	**			
	X8,17	Forklore Activity Area	**	**			

X1 Mountainous Zone
X2 Streams and Valleys Zone
X3 Farm Production Zone
X4 Forestry Preservation Zone
X5 Agricultural Zone
X7 Artificial Amusement Zone
X8 Relics and Temples Zone

Criteria for determining the development period of all subzones are as follows:

1. Take the development period of the homongeneous recreation site or the already developed scenic spots of

Taiwan, as reference.

2. Land area of each zone. The larger zones have longer development periods, while the smaller zones have shorter ones.

3. Those areas that have greater numbers and complexity of facilities have longer development periods; while those smaller in number and complexity have shorter ones.

4. In terms of investment returns of each subzone, those with the largest revenues have the shortest periods.

5. At present, on the sites already developed, only maintenance work is undertaken, thus the period is shorter.

9.3 Cash Flow Schedule and Net Present Value

Feasibility of the cash flow schedule and reliability of the expense estimation affect the outcome of the cost-benefit analysis and are also the basic work in planning and management.

This study is based on the theory discussed in section 6.3 of Chapter Six and the analysed results of the recreation resources and activities, as well as types of facilities, at Ta-keng Scenic Area. (section 7.7 of Chapter Seven) Calculate the net present value of each subzone. This is further explained as follows:

1. Acquisition of Land

Land cost is an important factor in the development costs of the recreation area. In this study, land price is based on the current public announcement of 1989. It adopts as cost a sectional price for land requisition, by combining the price of the land developed by private investment with the private land invested in by the government.

2. Cost of Construction Works

In a broad sense, the cost of construction works indicates a general building construction cost. In a recreation area, because the degree of development and types of facilities are not at the same stage, there are different construction items. In this study, the needed facilities of each subzone are planned according to the location of the subzone, patterns of existing resources, types of activities, facilities already available and the possibilities for further development of Ta-keng Scenic Area. (Table 9.2) Among these, the items, locations and areas of the public facilities are determined according to the current population, land use, communication, landscape and the future development trends of the planned area. In this study, besides the public facilities in Ta-keng Scenic Area planned for the urban development area, the future development model of each subzone is considered in order to provide enough public facilities -- including

Table 9.2 Construction Items of Ta-keng Scenic Area

Zones	Subzone	Items
X1	X1,1	Preservation Area Footpath, Car Park, Interpretation, Facilities, Litter Bins.
	X1,2	Physical Training Field, Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Public Lavatory, Physical Training Equipment, Wastes Treatment.
	X1,3	Camping Site Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Public Lavatory, Public Bath, Camping Tents, Barbecue Sets, Drinking Fountain, Sewerage Treatment, Wastes Treatment
	X1,4	Picnicking & Barbecuing Site Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Barbecue Site, Drinking Fountain, Sewerage Treatment, Wastes Treatment
	X1,5	Mountain Climbing Footpath Land Aquisition & Legal Fee, Footpath, Car Park, Public Lavatory, Interpretation, Facilities, Litter Bins
X2	X2,1	Preservation Area Footpath, Car Park, Interpretation, Facilities, Litter Bins
	X2,2	Physical Training Field Land Modelling Road Construction, Landscaping, Servicel Centre, Footpath, Car Park, Public Lavatory, Physical Training, Equipment, Wastes Treatment
	X2,3	Camping Site Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Public Lavatory, Public Bath, Camping Tents, Barbecue Set, Drinking Fountain, Sewerage Treatment, Wastes Treatment
	X2,4	Picninking & Barbecuing Site Land Modelling, Road Construction, Landscaping Service Centre Footpath, Car Park, Barbecue Set, Drinking Fountain, Sewerage Treatment, Wastes Treatment
	X2,5	Mountain Climbing Footpath Footpath, Car Park, Public Lavatory, Interpretation, Facilities, Litter Bins

Table 9.2 Construction Items Ta-keng Scenic Area (contd.)

Zones	Subzone	Items
X3	X3,1	Preservation Area Footpath, Car Park, Interpretation, Facilities, Litter Bins
	X3,2	Physical Training Field Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Public Lavatory, Physical Training, Equipment, Wastes Treatment
	X3,4	Picnicking & Barbecuing Site Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Barbecue Set, Drinking Fountain, Sewerage Treatment Wastes Treatment
	X3,5	Mountain Climbing Footpath Land Aquisition & Legal Fee, Footpath, Car Park, Public Lavatory, Interpretation, Facilities, Litter Binse
	X3,6	Tourist Orchard Area Land Aquisition & Legal Fee, Road Construction, Service Centre, Footpath, Car Park, Public Lavatory, Sewerage Treatment, Wastes Treatment
	X3,7	Hourse Riding Field Land Aquisition & Legal Fee, Road Construction, Landscaping, Administration, Office, Stable, Indoor Horse Riding, Field, Pasture, Car Park, Recreation Area, Tourist Centre, Wastes Treatment
	X3,8	Grass Skiing Field Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Car Park Public Lavatory, Footpath, Wastes Treatment
X4	X4,1	Forestry Preservation Area Footpath, Car Park, Public Lavatory, Interpretation, Facilities, Litter Bins
	X4,5	Mountain Climbing Footpath Footpath, Car Park, Public Lavatory, Interpretation, Facilities, Litter Bins
X5	X5,1	Farmscape Preservation Area Footpath, Car Park, Interpretation, Facilities Litter Bins

Table 9.2 Construction Items Ta-keng Scenic Area (contd.)

Zones	Subzone	Items
X7	X7,4	Picnicking & Barbecuing Site Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Public Lavatory, Car Park, Barbecue Set, Drinking Fountain, Sewerage Treatment, Wastes Treatment
	X7,6	Tourist Orchard Area Land Aquisition & Legal Fee, Footpath, Car Park, Road Construction, Service Centre, Public Lavatory, Wastes Treatment
	X7,8	Grass Skiing Field Land Aquisition & legal Fee, Road Construction, Landscaping, Service Centre, Car Park, Public Lavatory, Wastes Treatment
	X7,13	Mechanical Play Equipment Area, Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Public Lavator, Sitting Area, Recreation Area, Sewerage Treatment, Wastes Treatment
	X7,14	Tourist Centre Area Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Structure, Engineering, Finishing, Water & Electricity, Facilities, Car Park, Public Lavatory, Plaza, Interpretation, Facilities, Wastes Treatment
	X7,15	Garden Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Service Centre, Footpath, Car Park, Public Lavatory, Wastes Treatment
X8	X8,16	Relics & Temples Area Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping, Structure Engineering, Finishing, Water & Electricity, Car Park, Public Lavatory, Plaza, Interpretation, Facilities, Wastes Treatment
	X8,17	Forklore Activity Land Aquisition & Legal Fee, Land Modelling, Road Construction, Landscaping Car Park, Public Lavatory, Plaza, Interpretataion, Facilities,Wastes Treatment

roads, parking lots and children's playgrounds -- to promote the full realisation of the scenic area. The development costs - as used in this study, for each type of construction works mentioned above - are planned by referring to the presently developed sites in Taiwan, their facilities and the cost of construction of each item are shown in Appendix 9.1[1]

Criteria for purchasing land are the following :

(1) In recreation areas capable of maintaining the stability of the ecosystem and strengthening the effects of natural landscape there should be no land purchasing, no matter whether public or private ownership is involved (such as X1,1, X2,1, X3,1, X4,1 and X5,1).

(2) In areas that have the primary function of maintaining the ecosystem and strengthening the natural landscape, land used for public jogging paths should be purchased and managed by the government (such as X1,5, X2,5 and X3,5).

(3) In areas that have the function of maintaining the stability of the ecosystem and strengthening the natural landscape, small recreation spots should be no land purchasing (such as X2,3 and X2,4).

(4) At present, as well as in the future, the properties that have no change in land use and are managed by the farmers themselves should have no land purchasing (such as X7,6)

(5) In the areas sites with historical and educational values, including historical relics, religious and folk activities, there should be no purchasing (such as X8,16 and X8,17).

(6) Those areas not within the land purchase criteria mentioned above, all should be purchased.

3. Fixed Cost

Certain costs occur regardless of the quantity of each type of commodity produced and these are referred to as fixed costs.(2) In this study, fixed cost is the expense of construction work of Tung-Shan road (8000m in length and 20m in width). Periods for the construction work are two years. Fixed cash flow schedule of each year, present value of fixed cost and fixed cost of each zone are shown in Tables 9.3, 9.4 and 9.5, respectively.

Table 9.3 Fixed Cash Flow Schedule

Items	Year of Development		
	0	1	2
Land Aquisition & Legal Fee (1)	2,400,000	0	0
Road Construction(2)	0	40,000,000	40,000,000
Irrigation Equipment(3)	0	16,000,000	16,000,000
Electricity Facilities(4)	0	3,000,000	3,000,000
Interest	0	0	0
Total	2,400,000	59,000,000	59,000,000

(1) Average Land Price = N.T.$150/m*m (Current public announcement of 1989) (Note 1)

(2) Road construction cost = N.T.$500/m*m

(3) Irrigation equipment cost = N.T.$200/m*m (Note 2)

(4) Lighting : 40m in distance for each, N.T.$30,000 /each (Note 3)

Note 1. Data source from Peitwen District Council.

Note 2. Data source from Taichung City Council.

Note 3. Data Source from Taipei Park and Street Light Administration Office.

Table 9.4 Present Value of Fixed Cost

End of Year	Discount Factor	Outflow	P.V. of Outflow
0	1.0000	2,400,000	2,400,000
1	0.9524	59,000,000	56,191,600
2	0.9070	59,000,000	53,513,000
Total	- -	120,400,000	112,104,600

Table 9.5 Fixed Cost of Each Zone

zone	Ratio %	Fixed Cost (N.T.$)
X1	21.6	24,214,593
X2	46.0	51,568,116
X3	18.9	21,187,769
X7	10.8	12,107,297
X8	2.7	3,026,824

4. Interest

For capital cost estimation, if funds are borrowed from financial organisations, using the loan interest rates of the central bank or other common financial organisations in 1989 as the original fund interest rate, the interest on borrowing in this study is counted at 12%.

5. Investment Return

The development of a recreation area is a financial investment. As this is so, investment return must be emphasised. Whether it is great or small depends on the risk taken. In this study, the following principles are used to discriminate between high and low risks.

(1) High Risk

. Investment costs are extremely large and funds are not easily obtained.

. Development time is rather long and their maintenance is demanding.

. Facility types are numerous and their maintenance is demanding.

. Development potential is small and there is a lack of public facilities.

. Installations and facilities invested in have strong competition in the market.

(2) Average Risk

. Development costs are low and funds are easily obtained.

. Some development potentials and public facilities completed.

. Market competition is weak.

(3) Low Risk

. Amount of investment is small and returns on investment are forthcoming.

. There are fewer types of facilities and installations and they are easily maintained.

. There is no market competition.

Based on the principles mentioned above, the rate of return of each subzone in the study area is calculated. (Table 9.6)

Table 9.6 Rate of Return for Each Subzone

Sub-zone	Rate of return	Sub-zone	Rate of return	Sub-zone	Rate of return	Sub-zone	Rate of return
X1,1	9 %	X2,3	6 %	X3,6	12 %	X7,6	12 %
X1,2	15 %	X2,4	6 %	X3,7	30 %	X7,8	18 %
X1,3	12 %	X2,5	3 %	X3,8	18 %	X7,13	20 %
X1,4	12 %	X3,1	10 %	X4,1	5 %	X7,14	15 %
X1,5	10 %	X3,2	16 %	X4,5	3 %	X7,15	15 %
X2,1	5 %	X3,4	12 %	X5,1	10 %	X8,16	12 %
X2,2	6 %	X3,5	12 %	X7,4	15 %	X8,17	12 %

In this study, maximal investment return years of each subzone are specified to be the first and the second years after the development of that area has been completed. Criteria for determining the maximal development years of each subzone are as follows:

(1) The first year after development has been completed includes:

a. Present recreation sites on a smaller scale that have been developed or are still under development;

b. Recreation sites on a smaller scale, not yet developed, and with a smaller amount of investment;

c. Footpaths developed and undeveloped.

(2) The second year after development has been completed includes:

a. Recreation sites under consideration for development with high land prices and large investment;

b. Recreation sites presently under development and on a larger scale.

Cost and return of each subzone is shown in Table 9.7

6. <u>Rate of Discount</u>

The rate of discount adopted for general investment construction in Taiwan is of three types:[3][4]

(1) Government Borrowing Rate

This is the interest that has to be paid by the government or private sector when they borrow money from the central bank or other financial institutions and invest in constructions. Theoretically it is a risk-free interest rate.

(2) Bank Deposit Rate

If the funds are raised by the private sector and

Table 9.7 Cost and Return of Each Subzone(N.T.$/m*m)

Zone	Sub-zone	Unit-Cost (N.T.$/m*m)	Total Cost (N.T.$)	Unit-Return (N.T.$/m*m)	Total cost (N.T.$)
X1	X1,1	0.0154	206569.44	0.032	429235.20
	X1,2	162.57889	39571701.00	363.3558	88440801.00
	X1,3	148.01406	75687532.00	334.3994	169640810.00
	X1,4	151.4544	48207935.00	331.2234	105428400.00
	X1,5	111.91673	7543187.60	230.7646	15553534.00
X2	X2,1	0.07145	387566.23	0.147	797372.10
	X2,2	131.86419	27032158.00	310.57835	63668561.00
	X2,3	64.7264	13249494.00	124.7454	25535383.00
	X2,4	49.79204	16481165.00	95.9628	31763686.00
	X2,5	167.13499	22563223.00	389.98165	52647522.00
X3	X3,1	0.08223	387632.22	0.16928	797985.92
	X3,2	133.36444	62587931.00	302.2711	141855820.00
	X3,4	151.56218	25083540.00	331.72246	54900067.00
	X3,5	138.64148	17191543.00	305.13176	37836338.00
	X3,6	128.33447	92593320.00	284.14294	205009130.00
	X3,7	423.72398	305716850.00	1639.4487	707750000.00
	X3,8	221.25546	82749542.00	486.0432	181780150.00
X4	X4,1	0.11016	387102.24	0.229	804706.00
	X4,5	111.21064	9564115.00	214.33322	18432656.00
X5	X5,1	9.79	1958000.00	19.402	3880400.00
X7	X7,4	1284.8903	161382220.00	2844.5766	357278820.00
	X7,6	42.46846	2849633.6	2595.28124	174143360.00
	X7,8	392.8385	31466363.00	1104.0947	88437985.00
	X7,13	2644.19607	425715570.00	8619.1912	1387689700.00
	X7,14	1859.9504	136892430.00	6658.2635	490048190.00
	X7,15	1479.66214	196203190.00	3374.92516	447515060.00
X8	X8,16	2156.55083	129393040.00	6343.0598	380583580.00
	X8,17	1287.5991	115883910.00	2850.0928	256508350.00

are not used on that investment, but deposited in a bank or other financial institution, the interest is the bank deposit rate. Theoretically it is also a kind of risk-free interest rate. However, in this kind of interest rate the indirect costs and external factors are not considered. It does not reflect the returns on the funds in the course of an alternative investment, out of which a lower estimation of cost could result.

(3) Social Opportunity Cost

If private development companies are taken as a kind of completely competitive capital market, then the opportunity cost can be represented by the market interest rate. On the other hand, if it is not completely competitive, there is no interest rate that can sufficiently reflect the social opportunity cost of the funds.

In this study, the rate of discount adopted is of two kinds. If it is a private investment development, the opportunity cost is used as the rate of discount. If it is a government investment, no matter if it is on privately owned or on government owned land, the government borrowing rate is used as the rate of discount. The rate of discount for each subzone is shown in Table 9.8

Table 9.8 Rate of Discount of Each Subzone

Sub-zone	Rate of return	Sub-zone	Rate of return	Sub-zone	Rate of return	Sub-zone	Rate of return
X1,1	9 %	X2,3	5 %	X3,6	9 %	X7,6	9 %
X1,2	15 %	X2,4	5 %	X3,7	15 %	X7,8	12 %
X1,3	12 %	X2,5	3 %	X3,8	12 %	X7,13	12 %
X1,4	12 %	X3,1	9 %	X4,1	5 %	X7,14	12 %
X1,5	10 %	X3,2	12 %	X4,5	5 %	X7,15	12 %
X2,1	5 %	X3,4	12 %	X5,1	9 %	X8,16	12 %
X2,2	5 %	X3,5	10 %	X7,4	12 %	X8,17	12 %

7. Net present Value

Using formula (3) in section 6.3 of Chapter Six, the values of interest and revenue and rate of discount are substituted in and calculated. The result is the net present value of each subzone in Ta-keng Scenic Area. (Table 9.9)

Table 9.9 Net Present Value (N.P.V.) of Each Subzone

Sub-zone	N.P.V.	Sub-zone	N.P.V.	Sub-zone	N.P.V.	Sub-zone	N.P.V.
X1,1	0.0113	X2,3	42.5015	X3,6	47.4348	X7,6	594.9320
X1,2	71.4060	X2,4	32.6952	X3,7	865.6686	X7,8	322.1867
X1,3	50.3998	X2,5	155.3453	X3,8	103.6646	X7,13	3639.8505
X1,4	24.7178	X3,1	0.0345	X4,1	0.0806	X7,14	2785.7175
X1,5	8.5377	X3,2	54.8246	X4,5	69.5540	X7,15	822.8440
X2,1	0.0513	X3,4	60.5623	X5,1	4.7991	X8,16	2123.4018
X2,2	130.9264	X3,5	3.8479	X7,4	881.0772	X8,17	672.2375

9.4 Hypothesis and Conditions of the Model

1. From the results of the landuse suitability analysis in Chapter Seven (see section 7.7.2), it is known that the future land-use of Ta-keng Scenic Area can be classified into eight zones: mountainous zone (X1), streams and valleys zone (X2), farm production zone (X3), forestry preservation (X4), agricultural zone (X5), urban development zone (X6), artificial amusement zone (X7), and relics and temples zone (X8). Among these, the urban

development zone does not belong in the category of natural resources within the scope of this study. Therefore, this area is discounted. The land area used in the model is $32440000m^2$.

2. Those preservation areas which have weak geology, vegetation with water and soil retention functions, are situated in the drainage area, are evaluated as restricted development areas in this study (See section 7.6.4). They are to be developed on a small scale to maintain the ecological balance of Ta-keng Scenic Area. These areas include: X1,1, X2,1, X3,1, X4,1, X5,1.

3. After the analysis of proper activities and required facilities (Chapter Seven), each zone is subdivided into subzones as the "planning units". In this study, there are 28 planning units in total.

4. A balanced ecology is not easily obtained, and it is extremely vulnerable. So it is suggested that preservation areas in Ta-keng Scenic Area should be budgeted by the government in order to have sufficient manpower and funds for their proper management and maintenance. Whether the existing landownership is either government or private, no buying and selling should be allowed. It is also suggested that the recreation spots can be opened to the private sector for investment to satisfy national recreation demands and effective use of land.

5. At present, not only the government and the private sector has enough financial power and investment qualifications, but leisure time and the recreation population are increasing rapidly as well as the urgent demand for recreation area development. This study works out a five-year development plan for Ta-keng Scenic Area. It is supposed that through government and private sectors, and based on the planned recreation spots, the project will be carried out step by step according to the phases suggested in this study. Under the development potentials and constraints of the Scenic Area, the most efficient use of land will be obtained and the best conservation and use of the natural recreation resources of the area will be developed to the utmost.

9.5 Modelling

To achieve proper recreation resources management in Ta-keng Scenic Area, this study sets up three planning objectives: 1. the minimisation of physical-ecological carrying capacity; 2. the maximisation of social-psychological carrying capacity; and 3. the maximisation of return on investment. The structure of the general multiple objective linear programming model has been presented in Chapter Six. The model could be written in numerical form by using as input the recreation carrying capacity of each subzone (see Table 9.10) and the net present value of each subzone (see Table 9.9). Each numerical form of the model for land use alternatives contains three objectives, forty-six constraints and twenty-eight variables.

Table 9.10 Maximum Daily Physical-Ecological and Social-Psychological Carrying Capacities

Sub-zone	Phy-Eco C.C.	Soc-Psy C.C.	Sub-zone	Psy-Eco C.C.	Soc-Psy C.C.
X1,1	0.00003	0.00003	X3,6	0.007722	0.003267
X1,2	0.00470	0.001755	X3,7	0.015836	0.01712
X1,3	0.001813	0.001125	X3,8	0.00281	0.010538
X1,4	0.0026	0.000817	X4,1	0.000155	0.000043
X1,5	0.004334	0.004334	X4,5	0.002444	0.00454
X2,1	0.000021	0.000021	X5,1	0.00102	0.00084
X2,2	0.014753	0.009909	X7,4	0.021089	0.0190
X2,3	0.002364	0.001222	X7,6	0.032994	0.012831
X2,4	0.00370	0.003111	X7,8	0.00682	0.046035
X2,5	0.00294	0.00336	X7,13	0.076284	0.046618
X3,1	0.00015	0.000013	X7,14	0.001949	0.01067
X3,2	0.002131	0.00194	X7,15	0.04446	0.02603
X3,4	0.003555	0.001883	X8,16	0.060352	0.036432
X3,5	0.00042	0.00180	X8,17	0.03526	0.029455

9.6 Discussion and Conclusions of the Model

This case study of planning Ta-keng Scenic Area applies a MOLP model for analysis, which is solved by a software package, VIG. When considering the constraints of respective land areas of total Ta-keng Scenic area, each of the individual zones and the preservation areas as well as the development of each category of land use, the limited total budget, and the optimal areas of individual land uses are determined so that the physical-ecological carrying capacity is minimised, and the social-psychological carrying capacity and the investment return are maximised.

During the analysis, the Scenic Area is divided into eight zones and thirty two subzones. While zone six is an excluded urban development area, the rest of seven zones and twenty eight subzones are considered for modelling. Using Pareto Race of VIG, four non-dominated solutions are generated as alternatives and listed in Table 9.11. While the non-preemptive goal programming provided by VIG is adopted, the first one is generated by setting three goal values whereas the other three are giving each respective goal value and taking the rest two objectives as constraints for trade-off analysis.

Since all alternatives are nondominated, in order to determine the final satisatory plan, a comparison is carried out by measuring their distances from a reference point. This reference point in this study is obtained by solving three single objective LPs approximated by VIG to have the respective objective values of R = [r1, r2, r3] = [23180,153525,5.2993E+09]. Then the Eucledean distance between an alternative and the reference point is

Table 9.11 In Comparison of Nondominated solutions

Items		1**	2*	3*	4*
PECC	G1	35,537.758**	28,780.905*	55,000	55,000
SPCC	G2	60,923.653**	45,000	95,801.984*	55,500.687
NPV	G3	2.5723E+09**	1.900E+09	1.900E+09	3.8025E+09*
Preservation Area	X1,1	1.4197E+07	1.4426E+07	1.2606E+07	1.4585E+07
Physical Training Field	X1,2	80,000	80,000	80,000	80,000
Camping Site	X1,3	150,000	150,000	150,000	150,000
Picnicking & Barbecuing Site	X1,4	150,000	150,000	150,000	150,000
Mountain Climbing Footpath	X1,5	35,000	35,000	1,689,243	35,000
Preservation Area	X2,1	5,914,422	6,660,000	3,375,000	6,660,000
Physical Training Field	X2,2	60,000	60,000	60,000	60,000
Camping Site	X2,3	100,000	100,000	100,000	100,000
Picnicking & Barbecuing Site	X2,4	150,000	150,000	150,000	150,000
Mountain Climbing Footpath	X2,5	782,810	30,000	3,315,000	30,000
Preservation Area	X3,1	3,673,376.7	2,500,000	3,637,500	5,023,966.7
Physical Training Field	X3,2	180,000	180,000	180,000	180,000
Picnicking & Barbecuing Site	X3,4	75,000	75,000	75,000	75,000
Mountain Climbing Footpath	X3,5	50,000	3,539,015.6	50,000	50,000
Orchard Area	X3,6	350,000	350,000	350,000	350,000
Horse Riding Field	X3,7	70,876.708	70,000	233,903.74	2,042,033.3
Grass Skiing Field	X3,8	3,602,500	1,285,984.4	3,438,596.3	120,000
Forestry Preservation Area	X4,1	1,700,000	1,700,000	1,700,000	1,700,000
Mountain Climbing Footpath	X4,5	34,000	34,000	200,000	34,000
Farmscape Preservation Area	X5,1	100,000	100,000	100,000	100,000
Picnicking & Barbecuing Site	X7,4	25,000	25,000	25,000	25,000
Tourist Orchard Area	X7,6	15,000	15,000	15,000	15,000
Grass Skiing Field	X7,8	24,054	157,768	518,000	24,000
Mechnical Play Equipment Area	X7,13	99,991.572	100,000	100,000	100,000
Tourist Centre Area	X7,14	510,890.41	377,231.2	17,000	511,000
Garden	X7,15	25,000	25,000	25,000	25,000
Relice and Temple Area	X8,16	39,890.412	40,000	40,000	40,000
Forklore Activity Area	X8,17	25,000	25,000	25,000	25,000

(Header: Alternatives / Items)

* indicates the optimum solution of single objective

** indicates the compromise solution of MOLP defined by

$$di(G,R) = \left[\left|\frac{g1-r1}{r1}\right|^2 + \left|\frac{g2-r2}{r2}\right|^2 + \left|\frac{g3-r3}{r3}\right|^2 \right]^{1/2}$$

with G = [g1, g2, g3] being the objective values of (5) alternative i.

The result shows that d1(G,R) = 1.0719322, d2(G,R) = 0.9846464, d3(G,R) = 1.561175, d4(G,R) = 1.5400834, i.e. d3(G,R) > d4(G,R) > d1(G,R) > d2(G,R). That is, the alternative 2 is closer to the reference point that the others and in consequence, the alternative 2 can be adopted as the "satisfactory" land use plan of Ta-keng Scenic Area, of which the lower bound of the social-psychological carrying capacity and the investment return are restrained to minimise the physical-ecological carrying capacity. As the result, the low physical-ecological carrying capacity subzones as subzone(1,1) of preservation area of mountaneous zone, subzone (2,1) of streams and valleys zone, subzone (3,1) of farm production zone, and subzone (4,1) of forestry preservation area of forestry preservation zone; the high social-psycological carrying capacity subzones as subzone (3,5) of mountain climbing footpath of farm production zone and the high investment return subzone as subzone (3,8) of grass skiing field of farm production zone occupy relatively larger areas. This result reasonably matches our expectation of planning and the degree of satisfaction is reflected numerically by the metric distance.

In conclusion, although using Pareto Race to obtain a satisfactory solution is a normal process with VIG package, in order to show the pay offs among the objectives, a technique of constrained objectives is employed to generate four alternatives in total. Based on the concept of the more distant from the reference point the less satisfaction with the alternative, the final alternative with the greatest degree of satisfaction is determined from these four alternatives and that is alternative 2 as shown in Table 9.11. With the current assumption that the analyst is the decision maker, the result is reasonably matched with the analyst's observation and the expectation. If, however, the other authorised decision maker is not satisfied with the current sugesstion, he/she may use VIG to generate different satisfactory alternative with the proposed model. Therefore, from the theoretical and practical viewpoints, the recommended method is valid and feasible in recreation resource management. However, more exercises are needed in order to provide more information for effective decision making.

REFERENCES

1. Town and Country Consultant Company Limited : "Primary Plan of Ta-Kuan Mountain Scenic Area and Ta-Kuan Mountain Nature Reserve". (in Chinese), A Report to Tourism Bureau of Taiwan, ROC, 1988, pp. 66-67.

2. Kao, Hsi Jen : "The World of Economics". (in Chinese) The World Publishing Company, Taipei, ROC, 1987, p. 558.

3. Prest, A. R. and B. R. Turvey : "Cost-Benefit Analysis : A Survey". The Economic Journal, The Royal Economic Society, Oxford, England, 1965, p. 698.

4. Chang, Kin Yang : "Finance". (in Chinese) Wu Nan Publiching Company Limited, Taipei, ROC, 1976, pp. 175-176.

5. Zeleny, Milan : "Multiple Criteria Decision Making". McGraw-Hill Book Company, N.Y., U.S.A., 1982, pp. 107-108.

CHAPTER 10

SUMMARY AND CONCLUSION

In recreation resources planning and management both supply and demand have to be considered simultaneously. The former indicates the recreation resources and all their potentials including landscape, ecological, scientific and cultural values capable of being used for tourism and recreation to satisfy recreation demands. The latter refers to the users or visitors who are going to use these resources for their physical and psychological demands.

Context and Aim

The land area of Taiwan is limited, but it has innumerable natural recreation resources. Although the established recreation areas are significant, the recreation resources have not been well managed. One of the main causes is illogical planning and management for the following facts:

1. Insufficient theory and method often make the procedure and results of recreation resource planning invalid to planners.

2. Insufficient collection and analysis of basic information lead to invalid planning.

3. Neglect of recreation carrying capacity leads to a drop in recreation quality.

4. Placing higher priority on the development of

recreation resources, while neglecting their protection, leads to resource destruction.

5. Planning without consideration of costs and benefits leads recreation resources to insufficient use.

6. Planning without the involvement of professionals leads to the lessening of the quality of the environment and the recreation experience.

A recreation area includes various kinds of recreation resources and human activities, it is a complicated system with correlated factors. Therefore, in natural recreation resources management comprehensive planning of multipurpose uses must be taken into account. Several existing sociological and ecological methods have been adopted in the planning and management of natural recreation resource. But they either overvalue human demands and undervalue the environmental protection, or vice-versa. It is the purpose of the study to develop and evaluate resource management strategy for the recreation area in Taiwan to maintain a balanced relationship between human needs and these resources.

Methodology

The recommended method was a combination of the planning technique of Landscape Ecology Planning Method (LEPM) and the analysis technique of Multiple Objective Linear Programming (MOLP). It is suggested that in the first instance a preliminary planning structure for a recreation area should be formulated on the basis of land evaluation of LEPM. In the evaluation, critical affecting factors such as the existing acts and codes affected on the area, the visual quality of the site, types of recreation resources and the recreation demand should be analysed under the premise of the planning and management objectives of a recreation area. A preliminary land-use plan with land area and suitable activities of each recreation spot of the recreation area can thus be achieved.

Then, a decision model based on the concept and method of Multiple Objective Linear Programming technique which can handle planning problems involving multiple, incompatible objectives with trade-off analysis was presented by this study. The model could be solved by a software package VIG. A set of nondominated solutions were generated under the given contraints through Parato Race. Therefore, alternative management strategies of a recreation area could be presented to planner and manager to choose according to his preference, a satisfactory land use plan of a recreation area was also determined through a Eucledean distance comparison.

<u>Application</u>

In the application of the recommended method, the planning of Ta-Keng Scenic Area of Taiwan was considered as a case study. After the preliminary planning structure was carried out, social, ecological and economic quantified data were formulated based on the concepts of social-psychological and physical-ecological carrying capacities, and cost-benefit analysis, respectively.

As for the method of measuring recreation carrying capacities, this study selected them through strict evaluation. In terms of social-psychological carrying capacity, the study used visitor questionnaire and field observation of various complicated affecting factors, and obtained the "perception of tolerance" and "perception of crowdedness" data through a strict mathematical algorithm process, to find the social-psychological carrying capacity of each recreation spot of Ta-Keng Scenic Area.

In terms of physcial-ecological carrying capacity, the study used Analytic Hierarchy Process Method (AHP) by way of the professional's acknowledgement of the ecological problems and understanding of the Scenic Area. Through complex questionnaires and statistical analysis the physical-ecological carrying capacity of each recreation spot was found.

With regard to economics, this study used cost-benefit analysis in correlation with the development and planning of Ta-Keng Scenic Area to find the investment return of each spot expected, under the time frame, in order to properly employ the financial capabilities.

After the quantified data were found, they were submitted to the model developed by this study for discrimination. To achieve proper recreation resources management of a recreation area, this study set up three management objectives: 1.the minimisation of physical-ecological carrying capacity; 2.the maximisation of social-psychological carrying capacity; and 3.the maximisation of return on investment. When considering the constraints of respective land areas of Ta-Keng Scenic Area, each individual zones and the preservation areas as well as the development of each category of land use and limited total budget, the optimal areas of individual land uses were determined so that the physical-ecological carrying capacity was minimised, and the social-psychological carrying capacity and the investment return were maximised.

Using Parato Race of VIG four alternatives of land-use plan were generated. The result shows that all alternatives are nondominated and each of the alternatives presents a set of land areas of twenty eight subzones of Ta-keng Scenic Area under the premise of three objectives. Planner and manager can choose any one of the alternatives with their viewpoints. For example, recreationers can choose alternative 3 which a goal value was given to social objective while the rest two objectives were taken as constraints for trade-off analysis. As a result, the land area of subzones with higher social-psychological carrying capacity should be higher to satisfy the recreation demand as do the environmentalists and developers or investors who can choose alternatives 2 and 4, respectively.

However, the management objective of a recreation area is to obtain a balanced relationship between human needs and recreation resource while the investment return was also considered. Therefore, alternative 2 was suggested as the final satisfactory solution for the management of Ta-Keng Scenic Area on the basis of the concept of the more distant from the reference point the less satisfactory with the alternative. This reasonably matched our expectation of planning. Therefore, from the theoretical and practical viewpoints, the recommended method is valid and feasible in recreation resource management.

Contributions

In the application of the recommended method, it was found that it could provide the following information for recreation resource management of a recreation area from the analysis, synthesis of the detailed data formation and evaluation of the alternatives for a recreation area.

1. The method presents a management concept and a comprehensive planning structure for planners and managers involved in the natural recreation resource management.
2. Based on the consideration of sociological, ecological

and economic factors, a typical recreation area of Taiwan was adopted as a case study. Since the recommended method is objective, it is expected that the method can be applied to other similar recreation areas in the other countries but with some modification to suit the differing physical conditions.

3. The method can be used by central and local governments and private enterprise of Taiwan for development investment.

4. The method considered the tree major factors - sociological, ecological and economic simultaneously. Under the operation of the modelling, a nondominated solution could be obtained to provide decision makers who have different viewpoints in formulating management policies.

5. The study demonstrated that a reliable and rational resource management strategy of a recreation area can be generated under the operation of the model, with recreation carrying capacity of each recreation locality as a parameter. As a result, a recreation area with higher quality recreation resources and recreation experience can be determined by using this method.

6. The measurement of recreation carrying capacity presented in this study is complicated, but accurate. It is obvious that both social-psychological and physical-ecological carrying capacities of Ta-keng Scenic Area can be used as model for other similar recreation areas in Taiwan.

Evaluation and Further Study

The method proposed in this study is based on the concept of landscape ecology, using the availability of recreation resources and the constraints imposed by ecological conditions as the basis of appraisal of resource utilisation. Systematic analysis is applied to the analysis of the physical environment of recreation areas. The feasibility of resource utilisation is also built into the evaluation to avoid either overuse or the inadequate use of resources. Accordingly, what appear as spatial forms are land use categories and their regional distribution suitable for resource management.

Nonetheless, the basis on which the land is utilised is clearly qualitative but not exactly quantitative. It not only does not present the policy-makers with convincing blueprint for planning but also makes it difficult for the investors to assess the feasibility of land exploitation. In addition, owing to lack of reliable data, it is far from easy to cater to the protection of recreation resources and the increasing demand for recreation. Put another way, the proposition at issue is, while taking into account the potentiality and limitation together with the use of resources, how the land can be efficiently used so that maximum demand for recreation and cost-effectiveness can be met and reached under the premise of recreation resource protection.

Accordingly, this study further presents the notion of recreation carrying capacity, using physical-ecological carrying capacity and socio-psychological carrying capacity as indices, viz., the parameters in mathematical models for resource protection and satisfying demand for recreation respectively. The resources, constrained by physical-ecological carrying capacity, can then be effectively utilised for recreation activities, while the users can hope for recreation of higher quality limited by socio-psychological carrying capacity.

As to the aspect of economy, since this study highlights the standpoint of private management, net present value appears to be the most appropriate method of evaluation in terms of the principle of "minimum cost, maximum benefit" and the consideration of dynamic time factor.

As stated above, the use of land takes cognisance of the analysis of the suitability of ecosystems in relation to multipurpose managing indices for recreation resources. We now venture to propose an alternative to multiple-purpose use of land for consideration by policy-makers. In view of the fact that traditional methods of planning cannot effectively resolve the complex problem of multiple purpose uses, it becomes necessary to resort to multipurpose planning capable of solving conflicts between different multiple goals.

Because different mathematical models are used in different phases of decision-making in which the policy-makers are involved, and in order for the policy-makers not only to have chances to be actually engaged in the process of decision-making but also to learn other comparative procedures of feasible solutions, this study uses Multiple objective Linear Programming for decision-making analysis. It then applies the aforementioned objectives and constraints to the models put forward. All the data are then keyed in the computer package. A set of nondominated solutions will emerge with a visual interactive approach. The Euclidean distance of each solution is then calculated to find the most satisfactory nondominated solution. The outcome can not only provide the decision-makers with the effect of a policy as a basis for future evaluation of planning, but also enables them to avoid destruction or squandering of natural resources and poor investment in order to achieve a more efficient decision of policy on exploitation and development of recreation areas.

From the above analysis and evaluation, three features of the method proposed in this study can be specified as follows:

1. In securing the use of natural recreation resources, existing planning methods of managing resources are usually oriented to single objective, without taking other goals or aspects into consideration. Even if more than one goal is

considered, an objective and convincing result is hard to obtain. In particular, the mutual influence and conflict among the diverse goals cannot be effectively solved by the planning process.

On the other hand, the systems approach to the management of recreation resources as developed in this study concurrently takes sociological, economical and ecological factors into account. A compromise solution is reached through mathematical models, which is believed to be a better way to meet the demand for a carefully-planned management policy of recreation resources.

2. The method put forward in this study combines both the Landscape Ecology Planning Method(LEPM) and the Multiple Objective Linear Programming (MOLP). It not only strengthens the analytical capability of LEPM but also extends applicability of MOLP to the field of recreation resource management. By combining the two the areas of application are enlarged.

3. Contrasted with current application of carrying capacity, which employs the erroneous logic of the land area based on the carrying capacity calculated according to the use of land, the present study uses the physical-ecological carrying capacity and the socio-psychological carrying capacity as the parameters to be transferred into the mathematical models proposed in the study. The area of land use is then calculated through the operation of the

models. It not only corrects the application of recreation carrying capacity to derive a more feasible and credible solution, but also effectively uses measures of recreation carrying capacity as indices for controlling the qualities of environment and recreation.

However, the discussion in this research also leads to several topics worthy of further in-depth study. They are as follows.

1. As shown by the above analysis, multiple objective programming can substantially correct the weaknesses of the traditional method of recreation resource management in planning. However, by expanding the relevant knowledge and resources used, the current development of application will be restricted by the need to process massive amounts of data without in turn working out a system to help policy-makers make decisions. Accordingly, it becomes imperative that a Decision Support System (DSS) be established in the future for managing recreation resources and assisting the policy-makers to conduct the data analysis and evaluation of multiple objective programming so that policy-making can be more convincing and persuasive and more effective decisions can be reached.

2. The management of recreation resources is a complicated matter involving various dimensions. Thus, apart from the trend of multi-purpose management, the policy-makers, with whom planners deal, by no means speak

with a single voice but are likely to represent different interest groups or policy-makers at different phases. Because different policy-makers have their own preferences and purposes, the future mode of multiple objective programming can be integrated with the theory of Group Decision Making to probe the issue in a more thorough manner the better to fulfill practical requirements.

3. The preliminary land use plan as proposed in this study is a result of Landscape Ecology Planning Method. Only a part of the data is derived from the process of planning, however, it is analysed and traced through computer programs. The various areas of land use, as a result, have not yet been completely and accurately calculated. If, on the other hand, various complicated and detailed geographic data are integrated into systematic geographic data bank by using a Geographic Information System (GIS) and then analysed with the help of computer programs, processing data in the course of land planning can be more rapid and precise. Though it takes more manpower, time and money at the outset, the improvement in the method is worth the effort and the cost.

4. The whole process of the design of questionnaires, the training of the interviewers, the pilot test of the questionnaires, the screening of the returned questionnaires, and the complicated calculation in this study have been carefully prepared and conducted. However, further studies remain to be done as to whether tourists

were able accurately to judge the density of population of the unit area when they answer the questionnaires.

5. Up to this point, relative studies in planning and management of recreation resources, including the present one, give more weight to planning land use while ignoring the nature of recreation activities and the analysis of their feasibility. This not only leads to over-use of land and waste of natural resources, but also downgrades the quality of recreation and runs the risk of destroying the ecological environment. This being the case, how one establishes a proper allocation model for various recreation activities becomes another topic of concern in the future development of recreation areas.

6. Traditionally planning and the management of recreation resources mainly emphasise the discussion of the factors of "supply" and "demand." As a result, a substantial part of the resources has been unsystematically and sporadically exploited. This leads to competition where management of recreation areas is concerned, and greater uniformity and duplication of recreation experiences. This not only leads to squandering resources but also incurs financial loss by investors. Consequently, the mutual complementarity of recreation resources needs to be probed further and incorporated into the planning and management of recreation resources.

7. The management of recreational resources aims at protecting and nurturing resources and at securing high-level recreational opportunities. Thus, information about

tourists and the background data for planning should be updated on a regular basis so that the recreation resources can be accurately and efficiently evaluated and managed.

8. Natural recreation resources are the visible natural objects or scenery that can be appreciated by human beings. But most resource classification systems focus on visible stationary objects, whereas natural scenery such as sunrise, sunset, and evening clouds are nearly always ignored. How to include these intangible and ephemeral features in the planning system dealing with recreation resources is an issue demanding further investigation.

APPENDICES

Appendix 8.1 Survey Questionnaire for Ta-keng Scenic Area

There are two parts included in the survey questionnaire for Ta-keng Scenic Area : One is the survey questionnaire in which a letter for interviewees and the questionnaire are listed ; the other is the execution of the survey in which the training of interviewers and instructions for interviewers are described.

A. Survey questionnaire

A1. A letter for interviewees

Dear Sir or Madam;   February 2,1989

This is a questionnaire concerning visitors' social-psychological carrying capacity. It would be appreciated if you could spare a few minutes to answer the questions on the following pages.

This questionnaire is used for my research purposes only; no other uses will be made of it.

Thank you for your cooperation. I wish you a good time.

Sincerely yours,

Wang, Hsiao-Lin
Graduate School of
Architecture and Urban
Planning
Feng Chia University

A2. The questionnaire

Date: ________ ______ ______ Time: ______ ________

(mounth) (day) (year) (hour) (minute)

Place: ______________ Interviewer: ____________

(The follow questions are of single choice)

I. <u>Basic Information</u>

__________ 1. Gender:
a. male b. female

__________ 2. Age:
a. under 15 b. 15-24 c. 25-34 d.35-44
e. 45-54 f. 55-64 g. above 64

__________ 3. Education:
a. self-study b. primary school c. middle school d. high school(vocational) e. college/ university f. graduate school

__________ 4. Career:
a. public clerk b. student c. businessman
d. worker e. farmer, fisherman, rancher
f. service businessman g. housekeeper, none

__________ 5. Dwelling Place:
a. Taichung city b. Taichung county c. other central counties d. southern counties or cities e. eastern counties or cities f.northern counties or cities

__________ 6. Your companions are:
a. family, relatives b. none c. friends, colleagues d. schoolmates e. other social members

__________ 7. The number of your companions is:
a. none b. 1 c. 2-5 d. 6-10 e. 11-20
f. 21-40 g. >40

__________ 8. Your transportation is:
a. public bus b. private car c. tourist bus
d. taxi e. auto-bike f. bicycle g. on foot

__________ 9. How much will you spend (N.T.$):
a. < 300 b. 301-500 c.501-700 d. 701-1000
e. 1001-1500 f. 1501-2000 g. >2000

II. Perception of Crowdedness

__________ 10. At what number of visitors in the area would you begin to feel crowded ? (those who are mountain climbing or hiking, please answer b)

a. i. < 25/ha ii. 26-50/ha iii. 51-75/ha
iv. 76-100/ha v. 101-150/ha vi. 151-200/ha
vii. > 200/ha

b. i. < 3/km ii. 4-6/km iii. 7-10/km iv. 11-20/km
v. 21-30/km vi. 31-50/km vii. > 50/km

__________ 11. How many visitors within the activity-range can you tolerate ? (those who are mountain climbing or hiking, please answer b)

a. i. < 25/ha ii. 26-50/ha iii. 51-75/ha
iv. 76-100/ha v. 101-150/ha vi. 151-200/ha
vii. > 200/ha
b. i. < 3/km ii. 4-6/km iii. 7-10/km iv. 11-20/km
v. 21-30/km vi. 31-50/km vii. > 50/km

__________ 12. How many metres must be kept between visitors during the activity so that you would not feel crowded ?
a. 3m b. 4-6m c. 7-10m d. 11-20m
e. 21-30m f. 31-50m g. 50m

__________ 13. What is the frequency per hour that you can tolerate meeting other visitors, from the time of arrival to the time of the questionnaire ?
a. 1 b. 2-3 c. 4-5 d. 6-10 e. 11-20
f. 21-30 g. > 31

__________ 14. What is the most crowded hour for your activity ?
a. before 8 o'clock b. 8-10 o'clock
c. 10-12 o'clock d. 12-14 o'clock e. 14-16 o'clock f. 16-18 o'clock g. after 18 o'clock

__________ 15. How many visitors are there in this area ? (observed and recorded by interviewers)
a. < 20 b. 21-50 c. 51-100 d. 101-300
e. 301-500 f. 501-1000 g. > 1000

__________ 16. How many visitor-groups are there in this area: (observed and recorded by interviewers)
a. 1-2 b. 3-5 c. 6-10 d. 11-20 e. >20

III. Satisfaction Degree and the Intention to Revisit

__________ 17.How are you satisfied with this tour ?
a. very satisfied b. satisfied c. a little satisfied d. not satisfied e. very unsatisfied

__________ 18.Do you intend to make a revisit ?
a. will b. will not c. not certain

(The following questions are multiple choice. Answers chosen are no more than three).

IV. Motive, Outcome and the Reason to Not Make a Revisit

__________ 19.What are/is the prime motive at this time for making a Ta-keng visit ?
a. commune with nature b. increase social activity opportunities c. train physical ability d. increase knowledge e. relax

__________ 20.What are/is the greatest outcome of this visit ?
a. mentally satisfied b. knowledge increased
c. social activity opportunities increased
d. mentally relaxed e. enjoyment of beauty

__________ 21.What are/is the main cause of not willing to revisit
a. too many people b. no special view of the landscape c. area too messy
d. poor transportation e. no time
f. unable to meet the purpose of this visit

V. Direction of Development

__________ 22.What do you think the future development of Ta-keng Scenic Area should be ?
a. conserving natural landscape b. developing recreational facilities

B. Execution of the survey

B1. Training of interviewers

Survey work requires a number of specific skills and care should be taken in selecting staff. Interviewers should be capable of approaching people of all types and requesting their participation in the interviews. People who are shy and unwilling to approach people will not, generally, make good interviewers. The main requirement for both interviewers and observers is an ability to follow instructions carefully and to record information accurately.

Students are employed for site survey work. The survey director is drawn up a schedule for each survey day at the beginning of the survey period to ensure sufficient staff are available on all days. Allowance in the allocation of staff must be made for absences but discipline in relation to attendance is essential.

Experienced staff should be used when they are available but all survey staff require training. For all site surveys, a single day's training or briefing will be necessary. Briefing sessions fulfil two main purposes:

(a) informing staff of the general principles underlying survey work;

(b) familiarising staff with the objectives of the particular survey, the nature of the site, the questionnaire and the site survey arrangements.

Interviewers should conduct practice interviews with each other at the briefing sessions to ensure they are familiar with the questionnaire and understand the instructions contained in the questionnaire. The survey director should give clear instructions regarding:

(a) time of departure;

(b) time of return;

(c) allocation of staff on site;

(d) reminders about food and wet weather clothing;

(e) name and address of contact for any further details and cancellations.

This information should be explained at the initial briefing meeting and sent out before each survey day to each interviewer. On the first survey day the layout of the site should be explained to survey staff and any practical dealt with. If questions are asked relating to areas of the site visited, it is essential that interviewers are familiar with the layout of the site. Staff should be instructed never to leave their survey point unless given permission to do so by the supervisor or unless relieved by another member of the survey team as it is important that interviewing and observing are conducted throughout the survey day.

A supervisor is required for each site, and their duties are outline below.

(a) To deal with any problems or queries occurring on the survey day; in essence to respond to any situations arising on-site and to act accordingly.

(b) To perform a quality check on the work of the survey staff-questionnaires should be collected through the day and checked to ensure they have been completed correctly. Any errors should be reported back to interviewers.

(c) At the end of each survey day to ensure all work is checked and edited, that all schedules are accounted for, and all record forms are complete.

Supervisors are responsible to the survey director and should return all survey material to the project headquarters at the end of the survey day. Loss of questionnaires and observation schedules can mean the loss of a whole day's work and great care should be taken of all material. However well a survey may be designed, the first day in the field may well highlight one or two problems with the survey design. It is essential therefore, the supervisors and the survey director should meet at the end of the day to ensure any decisions that have been made are communicated to the survey team as a whole and any inconsistencies in decisions resolved.

Questionnaires and observation schedules should be numbered sequentially by individual interviewers/observers (i.e. given a field code) as they are completed to ensure that they are all accounted for at the end of the day. The interviewer's/observer's initials and a number, for example, SW1, SW2, SW3, etc. are most appropriate for this purpose. Depending on the nature of the site it is often desirable for staff to wear some form of identifying clothing to register their presence on the site and add authority to their task.

B2. Instructions for interviewers

1. Know the questionnaire thoroughly. Familiarity makes for a confident smooth delivery. Practice as much as possible on friends/relatives. The briefing session will include trial interviews with other members of the survey team.

2. No opinions either positive or negative should be expressed by the interviewer. The interviewer should be completely impartial but able to create an atmosphere in which the respondent feels relaxed and able to express himself. It is, however, important to control the interview in order to avoid digression or losing too much time in general conversation. Never argue with anyone about the purpose of the survey, no one is forced to participate, but ensure that you can explain the aims of the survey clearly and concisely.

3. Introduction of yourself is crucial and something which each interviewer must work out for him/herself, but the following points should be covered:
   (1) Who you are and the organisation you represent;
   (2) Sponsor for whom the work is being carried out;
   (3) Purpose of the survey;
   (4) Time it will take.

4. Types of questions

There are three types of information:

(1) Factual - Facts which exist in the present, e.g. age. There is a correct answer.

(2) Opinion - The questions must be asked as they are printed in the questionnaire.

(3) Knowledge - Can be confused with factual and description will depend on the site condition e.g. at what number of visitors in the area would you begin to feel crowded ?

5. Aids to obtaining information

(1) Probing Factual Questions - Ask question as printed in questionnaire, then:

Interviewer Check	Interviewer Action
(a) Was answer to your question relevant?	IF NOT Reword
(b) Was answer precise?	IF NOT Use aids (e.g. check list, etc.)
(c) Still no precise answer?	Accept estimate.

(2) Probing Opinion Questions

(a) Only printed questions can be used, and at no time can questions be reworded.

(b) If the question is not understood, repeat clearly. It still not understood, abandon and record why question not answered.

If an opinion question is missed out, it cannot be covered at the end of the interview - factual questions can.

(3) Prompting - A prompt is an implicit or explicit suggestion of an answer or possible answers to a question. Prompting should be avoided, because the interviewer introduces ideas and opinions of his own, which though taken up by the respondent are not necessarily his.

6. Recording techniques

This is a closed or forced choice questions, so ring appropriate code number, e.g. Do you intend to make a revisit?

will	1
will not	2
not certain	3

If respondent tries to qualify the answer, avoid it by saying 'On the whole, which answer comes nearest....'.

7. Selection of respondent

(1) After one interview is complete, interview the next person to approach you. Anybody over the age of 8 can be interviewed.

(2) Check if the person is - an employee
- resident in the park
- on business
- passing through.

If so, do not interview.

(3) Check if respondent has been interviewed before, if

yes, request a second interview explaining that you would like details of their visit that day as well.

(4) Finally, establish whether the person is leaving the site now, i.e., the visit is over. It is essential that the visit is complete before the interview takes place in order that all the details of the visit can be recorded.

Appendix 8.2 Observation Record Sheet

Date: ____________________

Place: ____________________

Activity Item: ____________________

Observer: ____________________

Time	No. of Tourist (person visit)	No. of Tourist Groups	Time	No. of Tourists (person visit)	No. of Tourist Groups
5:00-5:30			11:30-12:00		
5:30-6:00			12:00-12:30		
6:00-6:30			12:30-13:00		
6:30-7:00			13:00-13:30		
7:00-7:30			13:30-14:00		
7:30-8:00			14:00-14:30		
8:00-8:30			14:30-15:00		
8:30-9:00			15:00-15:30		
9:00-9:30			15:30-16:00		
9:30-10:00			16:00-16:30		
10:00-10:30			16:30-17:00		
10:30-11:00			17:00-17:30		
11:00-11:30			-----------		

Appendix 8.3. Questionnaire Data

Table 1. Visitor' Basic Data

Items	Attributes	No. of Visitors	Rate (%)	Total (%)
Gendar	Male	701	55.7	55.7
	Female	557	44.3	100.0
Age	< 15	58	4.6	4.6
	15-24	527	41.9	46.5
	25-34	275	21.9	68.4
	35-44	217	17.2	85.6
	45-54	112	8.9	94.5
	55-64	52	4.1	98.6
	> 64	17	1.4	100.0
Educational background	self-study	6	0.5	0.5
	primary school	63	5.0	5.5
	middle sch.	199	15.8	21.3
	high sch./voca.sch.	571	45.4	66.7
	college/univ.	402	32.0	98.6
	graduate sch.	17	1.4	100.0
Careers	public clerk	127	10.1	10.1
	Student	507	40.3	50.4
	businessman	243	19.3	69.7
	coorker	110	8.7	78.5
	farmer, fisherman	13	1.0	79.5
	service, businessman	139	11.0	90.5
	housekeeper, none	119	9.5	100.0
Dwelling places	Taichung city	615	48.9	48.9
	Taichung country	210	16.7	65.6
	other central cities	141	11.2	76.8
	southern countries or cities	185	14.7	91.5
	eastern counties or cities	3	0.2	91.7
	northern counties or cities	104	8.3	100.0
Companiors	families, relatives	548	43.6	43.6
	alone	30	2.4	45.9
	friends, colleagues	363	28.9	74.8
	schoolmates	261	20.7	95.5
	other social members	56	4.5	100.0
Number of companiors	alone	35	2.8	2.8
	1	181	14.4	17.2
	2-5	595	47.1	64.3
	6-10	234	18.6	82.9
	11-20	115	9.1	92.1
	21-40	27	2.1	94.2
	> 40	73	5.8	100.0
Transpor-tation	public bus	582	14.5	14.5
	private car	611	48.6	63.0
	tourist bus	103	8.2	71.2
	taxi	26	2.1	73.3
	auto-bike	292	23.2	96.5
	bicycle	7	0.6	97.1
	on foot	37	2.9	100.0
Willingness to spend	< 300.00	477	37.9	37.9
	301.00-500.00	287	22.8	60.7
	501.00-700.00	147	11.7	72.4
	701.00-1000.00	199	15.3	88.2
	1001.00-1500.00	71	5.6	93.9
	501.00-2000.00	36	2.9	96.7
	> 2000.00	41	3.3	100.0

Table 2. Recreation Activities Data

a. Activities	landscape observation	400	31.8	31.8
	picnicking barbecuing	128	10.2	42.0
	camping	73	5.8	47.8
	artificial amusement	143	11.4	59.1
	physical training	168	13.4	72.5
	temple visiting	207	16.5	89.0
	mountain climbing	139	11.0	100.0
b. Dates	special holiday	505	40.1	40.1
	routine holiday	412	32.8	72.9
	weekday	341	27.1	100.0
c. Times	before 8:00a.m.	54	4.3	4.3
	8:00-10:00	180	14.3	18.6
	10:00-12:00	343	27.3	45.9
	12:00-14:00	304	24.2	70.0
	14:00-16:00	273	21.7	91.7
	16:00-18:00	104	8.3	100.0
	after 18:00	0	0	0
d. Numbers of visitor	< 20 persons	181	14.6	14.6
	21-50 "	207	16.5	31.1
	51-100 "	214	17.0	48.1
	101-300 "	489	38.9	87.0
	301-500 "	91	7.2	94.2
	501-1000 "	73	5.8	100.0
	> 1000 "	0	0	0
e. Numbers of visitor group	1-2	189	15.0	15.0
	3-5	272	21.6	36.6
	6-10	280	22.3	58.9
	11-20	202	16.1	75.0
	> 20	314	25.0	99.9

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Table 3. Perception of Crowdedness Data

a. Threshold number of persons at which visitors begin to feel crowded	Q(a)	< 25 per./ha	46	4.1	4.1
		26-50 "	124	11.1	15.2
		51-75 "	296	26.5	41.6
		76-100 "	296	26.5	68.1
		101-150 "	107	14.9	83.0
		151-200 "	106	9.5	92.5
		> 200 "	84	7.5	100.0
	Q(b)	< 3 per./km	5	3.6	3.6
		4-6 "	12	8.6	12.2
		7-10 "	30	21.6	33.8
		11-20 "	35	25.2	59.0
		21-30 "	14	10.1	69.1
		31-50 "	15	10.8	79.9
		> 50 "	28	20.1	100.0
b. Maximum Tolerance of visitor numbers	Q(a)	< 25 per./ha	35	3.1	3.1
		26-50 "	78	7.0	10.1
		51-75 "	128	11.4	21.5
		76-100 "	272	24.3	45.8
		101-150 "	202	18.1	63.9
		151-200 "	200	17.9	81.8
		> 200 "	204	18.2	100.0
	Q(b)	< 3 per./km	3	2.2	2.2
		4-6 "	6	4.3	6.5
		7-10 "	26	18.7	25.2
		11-20 "	31	22.3	47.5
		21-30 "	17	12.2	59.7
		31-50 "	19	13.7	73.4
		> 50 "	37	26.6	100.0
c. Preferred Interpersonal Distance		< 3m	172	13.7	13.7
		4-6m	372	29.6	43.2
		7-10m	374	29.7	73.0
		11-20m	190	15.1	88.1
		21-30m	64	5.1	93.2
		31-50m	29	2.3	95.5
		> 50m	57	4.5	100.0
d. Maximum Tolerance of Encounters Frequencies		1	55	4.4	4.4
		2-3	236	18.8	23.1
		4-5	291	23.1	46.3
		6-10	370	29.4	75.7
		11-20	132	10.5	86.2
		21-30	60	4.8	90.9
		> 31	114	9.1	100.0
e. Most Crowded Hour		before 8:00am	114	9.1	9.1
		8:00-10:00	87	6.9	16.0
		10:00-12:00	280	22.3	38.2
		12:00-14:00	201	16.0	54.2
		14:00-16:00	160	12.7	66.9
		16:00-18:00	317	25.2	92.1
		after 18:00	99	7.9	100.0

Table 4. Cross-Analysis Data of Recreation Activities and Visitor Characteristics

Recreation Activities \ Visitor Data		gender: male	female
landscape observation		195	205
	%	15.5	16.3
Picnicking barbecuing		67	61
	%	5.3	4.8
Camping		45	28
	%	3.6	2.2
artificial amusement		92	51
	%	7.3	4.1
physical training		102	66
	%	8.1	5.2
temple visiting		106	101
	%	8.4	8
mountain climbing hiking		94	45
	%	7.5	3.6

X*X = 25.20 P-value = 0.0003

Recreation Activities \ Visitor Data		age: <25	25-34	35-44	45-54	>54
landscape observation		224	84	49	29	14
	%	17.8	6.7	3.9	2.3	1.1
Picnicking barbecuing		62	23	30	11	2
	%	4.9	1.8	2.4	0.9	0.2
Camping		68	3	1	0	1
	%	5.4	0.2	0.1	0	0.1
artificial amusement		96	24	10	8	5
	%	7.6	1.9	0.8	0.6	0.4
physical training		63	36	40	17	12
	%	5	2.9	3.2	1.4	1
temple visiting		41	74	58	19	15
	%	3.3	5.9	4.6	1.5	1.2
mountain climbing hiking		31	31	29	28	20
	%	2.5	2.5	2.3	2.2	1.6

X*X = 247.36 P-value = 0.0000

Recreation Activities \ Visitor Data		educational backgroud: under Pri.sch.	middle sch.	high sch. voca.sch.	above collegeuni
landscape observation		8	49	205	138
	%	0.6	3.9	16.3	11
Picnicking barbecuing		6	23	62	37
	%	0.5	1.8	4.9	2.9
Camping		1	23	35	14
	%	0.1	1.8	2.8	1.1
artificial amusement		6	9	79	49
	%	0.5	0.7	6.3	3.9
physical training		21	34	54	59
	%	1.7	2.7	4.3	4.7
temple visiting		13	47	82	65
	%	1	3.7	6.5	5.2
mountain climbing hiking		14	14	54	57
	%	1.1	1.1	4.3	4.5

X*X = 90.65 P-value = 0.0000

Table 4. Cross-Analysis Data of Recreation Activities and Visitor Characteristics (Contd.)

Recreation Activities \ Visitor Data	dwelling place: Taichung city	Taichung county	other central cities	southern counties or cities	eastern counties or cities		no. of companions: < 2 per.	2-5 "	6-10 "	11-20 "	> 20	
landscape observation	67	63	86	109	75	X*X = 529.37 P-value = 0.0000	56	201	70	22	51	X*X = 407.12 P-value = 0.0000
%	5.3	5	6.8	8.7	6		4.5	16	5.6	1.7	4.1	
Picnicking barbecuing	98	16	4	7	3		9	35	50	30	4	
%	7.8	1.3	0.3	0.6	0.2		0.7	2.8	4	2.4	0.3	
Camping	40	15	0	17	1		0	8	14	24	27	
%	3.2	1.2	0	1.4	0.1		0	0.6	1.1	1.9	2.1	
artificial amusement	29	22	27	45	20		19	59	28	23	14	
%	2.3	1.7	2.1	3.6	1.6		1.5	4.7	2.2	1.8	1.1	
physical training	123	36	3	4	2		18	105	33	11	1	
%	9.8	2.9	0.2	0.3	0.2		1.4	8.3	2.6	0.9	0.1	
temple visiting	144	37	20	2	4		69	122	16	0	0	
%	11.4	2.9	1.6	0.2	0.3		5.5	9.7	1.3	0	0	
mountain climbing hiking	114	21	1	1	2		45	63	23	5	3	
%	9.1	1.7	0.1	0.1	0.2		3.6	5	1.8	0.4	0.2	

Table 4. Cross-Analysis Data of Recreation Activities and Visitor Characteristics (Contd.)

Visitor Data / Recreation Activities	career: public clerk	career: student	career: business-men	career: farmer, fisherman rancher worker	career: service business-men	career: house keeper, none		companions: families relatives alone.	companions: friends, colleagues	companions: school mates	companions: social member	
landscape observation	42	198	54	33	49	24	X*X = 225.03 P-value = 0.0000	130	145	123	2	X*X = 470.82 P-value = 0.0000
%	3.3	15.7	4.3	2.6	3.9	1.9		10.3	11.5	9.8	0.2	
Picnicking barbecuing	10	49	27	17	14	11		71	23	24	10	
%	0.8	3.9	2.1	1.4	1.1	0.9		5.6	1.8	1.9	0.8	
Camping	3	61	3	2	3	1		1	14	29	29	
%	0.2	4.8	0.2	0.2	0.2	0.1		0.1	1.1	2.3	2.3	
artificial amusement	17	82	20	9	12	3		41	49	51	2	
%	1.4	6.5	1.6	0.7	1	0.2		3.3	3.9	4.1	0.2	
physical training	25	57	40	21	9	16		107	52	9	0	
%	2	4.5	3.2	1.7	0.7	1.3		8.5	4.1	0.7	0	
temple visiting	18	38	62	18	35	36		154	34	15	4	
%	1.4	3	4.9	1.4	2.8	2.9		12.2	2.7	1.2	0.3	
mountain climbing hiking	12	22	37	23	17	28		74	46	10	9	
%	1	1.7	2.9	1.8	1.4	2.2		5.9	3.7	0.8	0.7	

Table 4. Cross-Analysis Data of Recreation Activities and Visitor Characteristics (Contd.)

Visitor Data / Recreation Activities		transportation						
		public bus	private bus	tourist bus	taxi	autobike	bicycle on foot	
landscape observation		76	147	77	4	89	7	X*X = 464.83 P-value = 0.0000
	%	6	11.7	6.1	0.3	7.1	0.6	
Picnicking barbecuing		1	82	1	0	43	1	
	%	0.1	6.5	0.1	0	3.4	0.1	
Camping		24	9	5	1	22	12	
	%	1.9	0.7	0.4	0.1	1.7	1	
artificial amusement		55	52	19	1	16	0	
	%	4.4	4.1	1.5	0.1	1.3	0	
physical training		5	117	1	1	44	0	
	%	0.4	9.3	0.1	0.1	3.5	0	
temple visiting		9	106	0	19	55	18	
	%	0.7	8.4	0	1.5	4.4	1.4	
mountain climbing hiking		12	98	0	0	23	6	
	%	1	7.8	0	0	1.8	0.5	

Visitor Data / Recreation Activities		willingness to spend						
		< 300 NT$	301-500	501-700	701-1000	1001-1500	> 1500	
landscape observation		84	87	77	88	34	30	X*X = 511.33 P-value = 0.0000
	%	6.7	6.9	6.1	7	2.7	2.4	
Picnicking barbecuing		59	38	15	13	2	1	
	%	4.7	3	1.2	1	0.2	0.1	
Camping		23	45	1	1	0	3	
	%	1.8	3.6	0.1	0.1	0	0.2	
artificial amusement		38	31	17	21	17	19	
	%	3	2.5	1.4	1.7	1.4	1.5	
physical training		111	26	22	8	1	0	
	%	8.8	2.1	1.7	0.6	0.1	0	
temple visiting		32	55	14	65	17	24	
	%	2.5	4.4	1.1	5.2	1.4	1.9	
mountain climbing hiking		130	5	1	3	0	0	
	%	10.3	0.4	0.1	0.2	0	0	

Table 5. Cross-Analysis Data of Recreation Activities and Preferred Interpersonal Distance, Maximum Tolerance of Encounters Frequency and Most Crowded Hours

		A	%	B	%	C	%	D	%	E	%	F	%	G	%	total
age	< 3m	24	1.9	16	1.3	11	0.9	39	3.1	49	3.9	0	0	33	2.6	172.0
	4-6m	97	7.7	49	3.9	17	1.4	51	4.1	73	5.8	56	5.2	19	1.5	372.29
	7-10m	139	11	26	2.1	14	1.1	30	2.4	35	2.8	114	9.1	16	1.3	374.29
	11-20m	85	6.8	16	1.3	11	0.9	12	1	9	0.7	26	2.1	30	2.4	190.15
	21-30m	29	2.3	8	0.6	2	0.2	4	0.3	1	0.1	0	0	20	1.6	69.5
	31-50m	13	1	4	0.3	3	0.2	0	0	0	0	1	0.1	8	0.6	29.2
	> 50m	12	1	9	0.7	15	1.2	7	0.6	1	0.1	0	0	13	1	57.4
X*X = 382.19 P-value = 0.0000																
maximum tolerance of encounters frequency	1	25	2.9	5	0.4	10	0.8	9	0.7	0	0	2	0.2	4	0.3	55.4
	2-3	43	3.4	37	2.9	12	1	38	3	58	4.6	36	2.9	12	1	136.1
	4-5	73	5.8	31	2.5	21	1.7	19	1.5	66	5.2	67	5.3	14	1.1	291.2
	6-10	138	11	35	2.8	10	0.8	22	1.7	38	3	88	7	39	3.1	370.2
	11-20	67	5.3	11	0.9	10	0.8	8	0.6	4	0.3	12	1	20	1.6	132.1
	21-30	39	3.1	3	0.2	2	0.2	5	0.4	1	0.1	1	0.1	9	0.7	60.4
	> 31	15	1.2	6	0.5	8	0.6	42	3.3	1	0.1	1	0.1	41	3.3	141.91
X*X = 419.80 P-value = 0.0000																
most crowded hours	before 8:00	0	0	6	0.5	7	0.6	1	0.1	17	1.4	12	1	71	5.6	114.9
	8:00-10:00	22	1.7	7	0.6	5	0.4	5	0.4	16	1.3	0	0	32	2.5	87.6
	10:00-12:00	78	6.2	54	4.3	16	1.3	39	3.1	71	5.6	1	0.1	21	1.7	280
	12:00-14:00	55	4.4	45	3.6	14	1.1	28	2.2	46	3.7	0	0	13	1	201
	14:00-16:00	67	5.3	9	0.7	7	0.6	58	4.6	18	1.4	0	0	1	0.1	160.1
	16:00-18:00	103	8.2	6	0.5	7	0.6	12	1	0	0	188	14.9	1	0.1	317.
	after 18:00	75	6	1	0.1	17	1.4	0	0	0	0	6	0.5	0	0	99.7
X*X = 1326.37 P-value = 0.0000																

A = landscape observation
B = picnicking, barbecuing
C = camping
D = artificial amusement
E = physical training
F = temple visiting
G = mountian climbing

Table 6. Cross-Analysis Data of Recreation Activities and Number of Visitors

Analysis Item \ Recreation Activities		A	%	B	%	C	%	D	%	E	%	F	%	G	%
nos. of vistor	< 21 persons	16	1.3	0	0	2	0.2	27	2.1	23	1.8	56	4.5	60	4.8
	21-50	71	5.6	0	0	0	0	39	3.1	13	1	21	1.7	63	5
	51-100	116	9.2	10	0.8	5	0.4	21	1.7	10	0.8	37	2.9	15	1.2
	101-300	178	14.1	77	6.1	0	0	55	4.4	87	6.9	92	7.3	0	0
	301-500	19	1.5	27	2.1	0	0.1	1	0.1	35	2.8	1	0.1	1	0.1
	> 500	0	0	14	1.1	0	0	0	0	0	0	0	0	0	0
X*X = 1340.13 P-value = 0.0000															
nos. of vistor group	1-2 groups	37	2.7	2	0.2	44	3.5	44	3.5	13	1	20	1.6	29	2.3
	3-5	86	6.8	45	3.6	7	0.6	24	1.9	10	0.8	37	2.9	63	5
	6-10	92	7.3	46	3.7	21	1.7	43	3.4	16	1.3	17	1.4	45	3.6
	11-20	106	8.4	0	0	1	0.1	32	2.5	23	1.8	38	3	2	0.2
	> 20	79	6.3	35	2.8	0	0	0	0	105	8.4	95	7.6	0	0
X*X = 593.04 P-value = 0.0000															

A = landscape observation B = picnicking, barbecuing

C = camping D = artificial amusement

E = physical training F = temple visiting

G = mountian climbing

Table 7. <u>Cross-Analysis Data of Perception of Tolerance and Visitor Characteristics</u>

Visitor Data / perception of Tolerance (per./ha per./km)				age					educational backgroud			
		male	female	<25	25-34	35-44	45-54	>54	under pri.sch.	middle sch.	high sch/ voca.sch.	above collegeuni.
< 50	A*	53	69	96	10	10	3	3	4	21	61	36
< 6	%	4.2	5.5	7.6	0.8	0.8	0.2	0.2	0.3	1.7	4.8	2.9
51-75	A*	80	74	79	29	24	14	8	7	23	87	37
7-10	%	6.4	5.9	6.3	2.3	1.9	1.1	0.6	0.6	1.8	6.9	2.9
76-100	A*	173	130	122	82	58	26	15	16	54	134	99
11-20	%	13.8	10.3	9.7	6.5	4.6	2.1	1.2	1.3	10.3	10.7	7.9
101-150	A*	124	95	91	48	47	19	14	10	38	92	79
21-30	%	9.9	7.6	7.2	3.8	3.7	1.5	1.1	0.8	3	7.3	6.3
151-200	A*	123	96	91	57	38	23	10	10	34	99	76
31-50	%	9.8	7.6	7.2	4.5	3	1.8	0.8	0.8	2.7	7.9	6
> 200	A*	148	93	106	49	40	27	19	22	29	98	92
> 50	%	11.8	7.4	8.4	3.9	3.2	2.1	1.5	1.7	2.3	7.8	7.3
Discrepancy Analysis between Variables		X*X=11.83 P-value= =0.0372		X*X=72.13 P-value=0.0000					X*X=24.85 P-value=0.0519			

Table 7. Cross-Analysis Data of Perception of Talerance and Visitor Characteristics (Contd.)

Visitor Data / perception of Toler ance (per./ha per./km)		career						dwelling place				
		public clerk	student	business-men	farmer, fisherman rancher worker	service business-men	hse. keeper, none	Taichung city	Taichung county	other central cities	southern counties or cities	eastern counties or cities
< 50	A*	9	79	9	6	15	4	43	17	7	34	21
< 6	%	0.7	6.3	0.7	0.5	1.2	0.3	3.4	1.4	0.6	2.7	1.7
51-75	A*	8	72	28	10	19	17	80	20	13	30	11
7-10	%	0.6	5.7	2.2	0.8	1.5	1.4	6.4	1.6	1	2.4	0.9
76-100	A*	32	112	59	32	31	37	63	50	36	40	14
11-20	%	2.5	8.9	4.7	2.5	2.5	2.9	1.3	4	2.9	3.2	1.1
101-150	A*	18	74	47	35	24	21	91	47	36	27	18
21-30	%	1.4	5.9	3.7	2.8	1.9	1.7	7.2	3.7	2.9	2.1	1.4
151-200	A*	29	75	53	22	24	16	109	43	18	22	27
31-50	%	2.3	6	4.2	1.7	1.9	1.3	8.7	3.4	1.4	1.7	2.1
> 200	A*	31	95	47	18	26	24	129	33	31	32	16
> 50	%	2.5	7.6	3.4	1.4	2.1	1.9	10.3	2.6	2.5	2.5	1.3
Discrepancy Analysis between Variables		X*X=70.86 P-value=0.0000						X*X=72.29 P-value=0.0000				

Table 7. Cross-Analysis Data of Perception of Talerance and Visitor Characteristics (Contd.)

Visitor Data / perception of Toler ance (per./ha per./km)		no. of companions: alone	2-5 per.	6-10 "	11-20 "	> 20 "	companions: family relatives alone	friends, colleag-use	school-mates	social member
< 50 < 6	A* %	22 1.7	47 3.7	23 1.8	47 1.4	13 1	27 2.1	41 3.3	46 3.7	8 0.6
51-75 7-10	A* %	35 2.8	57 4.5	29 2.3	25 2	8 0.6	60 4.8	44 3.5	36 2.9	14 1.1
76-100 11-20	A* %	66 5.2	156 12.4	45 3.6	21 1.7	15 1.2	161 12.8	79 6.3	57 4.5	6 0.5
101-150 21-30	A* %	33 2.6	117 9.3	44 3.5	10 0.8	15 0.2	109 8.7	66 5.2	36 2.9	8 0.6
151-200 31-50	A* %	31 2.5	115 9.1	38 3	17 1.4	18 1.4	116 9.2	66 5.2	33 2.6	4 0.3
> 200 > 50	A* %	29 2.3	110 8	55 4.4	25 2	31 2.5	105 8.3	67 5.3	53 4.2	16 1.3
Discrepancy Analysis between Variables		X*X=60.84 P-value=0.0000					X*X=68.19 P-value=0.0000			

Table 7. Cross-Analysis Data of Perception of Talerance and Visitor Characteristics (Contd.)

Visitor Data / perception of Tol-ar ance (per./ha per./km)		willingness to spend						transportation					
		< 300 NT$	301-500	501-700	701-1000	1001-1500	> 1500	public bus	private bus	tourist bus	taxi	autobike	bicycle, or foot
< 50 < 6	A* %	60 4.8	37 2.9	4 0.3	10 0.8	3 0.2	8 0.6	25 2	41 3.3	16 1.3	1 0.1	33 2.6	6 0.5
51-75 7-10	A* %	70 5.6	44 3.5	12 1	16 1.3	8 0.6	4 0.3	22 1.7	63 5	9 0.7	6 0.5	40 3.2	14 1.1
76-100 11-20	A* %	115 9.1	68 5.4	27 2.1	60 4.8	13 1	20 1.6	30 2.4	154 12.2	25 2	11 0.9	7 5.6	12 1
101-150 21-30	A* %	65 5.2	46 3.7	41 3.3	35 2.8	20 1.6	12 1	41 3.3	107 8.5	14 1.1	5 0.4	48 3.8	4 0.3
151-200 31-50	A* %	73 5.8	40 3.2	36 2.9	44 3.5	9 0.7	17 1.4	21 1.7	122 9.7	19 1.5	2 0.2	3 4:1	1.7 0.2
> 200 > 50	A* %	94 7.5	52 4.1	27 2.1	34 2.7	18 1.4	16 1.3	43 3.4	124 9.9	20 1.6	1 0.1	48 3.8	5 0.4
Discrepancy Analysis between Variables		X*X=72.49 P-value=0.0000						X*X=65.65 P-value=0.0000					

Table 8. Cross-Analysis Data of Perception of Crowdedness and Visitor Characteristics

Visitor Data / perception of Toler ance (per./ha per./km)		gender		age					educational backgroud			
		male	female	<25	25-34	35-44	45-54	>54	under pri.sch.	middle sch.	high sch/ voca.sch.	above collegeuni.
< 50	A*	94	93	118	26	26	11	6	12	25	90	60
< 6	%	7.5	7.4	9.4	2.1	2.1	0.9	0.5	1	2	7.2	4.8
51-75	A*	171	155	172	60	49	26	19	15	52	164	95
7-10	%	13.6	12.3	13.7	4.8	3.9	2.1	1.5	1.2	4.1	13	7.6
76-100	A*	195	136	103	105	74	29	20	18	55	135	123
11-20	%	15.5	10.8	8.2	8.3	5.9	2.3	1.6	1.4	4.4	10.7	9.8
101-150	A*	95	86	70	45	39	20	7	10	34	76	61
21-30	%	7.6	6.8	5.6	3.6	3.1	1.6	0.6	0.8	2.7	6	4.8
151-200	A*	68	83	63	24	16	16	2	7	18	57	39
31-50	%	5.4	4.2	5	1.9	1.3	1.3	0.2	0.6	1.4	4.5	3.1
> 200	A*	78	34	59	15	13	10	15	7	15	49	41
> 50	%	6.2	2.7	4.7	1.2	1	0.8	1.2	0.6	1.2	3.9	3.3
Discrepancy Analysis between Variables		X*X=14.61 P-value= =0.012		X*X=98.25 P-value=0.0000					X*X=11.11 P-value=0.7447			

Table 8. Cross-Analysis Data of Perception of Crowdedness and Visitor Characteristics(Contd.)

Visitor Data / perception of Toler ance (per./ha per./km)		career						dwelling place				
		public clerk	student	business -men	farmer, fisherman rancher worker	service business-men	hse. keeper, none	Taichung city	Taichung county	other central cities	southern counties or cities	eastern counties or cities
< 50	A*	12	94	23	14	29	15	74	20	20	47	26
< 6	%	1	7.5	1.8	1.1	2.3	1.2	5.9	1.6	1.6	3.7	2.1
51-75	A*	33	158	55	25	28	27	169	48	37	54	18
7-10	%	2.6	12.6	4.4	2	2.2	2.1	13.4	3.8	2.9	4.3	1.4
76-100	A*	34	90	82	42	45	38	163	75	43	26	24
11-20	%	2.7	7.2	6.5	3.3	3.6	3	13	6	3.4	2.1	1.9
101-150	A*	26	59	46	18	14	18	81	35	19	25	21
21-30	%	2.1	4.7	3.7	1.4	1.1	1.4	6.4	2.8	1.5	2	1.7
151-200	A*	10	54	20	15	15	7	63	19	12	16	11
31-50	%	0.8	4.3	1.6	1.2	1.2	0.6	5	1.5	1	1.3	0.9
> 200	A*	12	52	17	9	8	14	65	13	10	17	7
> 50	%	1	4.1	1.4	0.7	0.6	1.1	5.2	1	0.8	1.4	0.6
Discrepancy Analysis between Variables		X*X=72.84 P-value=0.0000						X*X=61.53 P-value=0.0000				

Table 8. Cross-Analysis Data of Perception of Crowdedness and Visitor Characteristics(Contd.)

Visitor Data / perception of Toler ance (per./ha per./km)		companions				no. of companions				
		family relatives alone	friends, colleagues	school-mates	social member	alone	2-5 per.	6-10 "	11-20 "	> 20 "
< 50 < 6	A* %	62 4.9	64 5.1	57 4.5	4 0.3	35 2.8	80 6.4	34 2.7	19 1.5	19 1.5
51-75 7-10	A* %	153 12.2	80 6.5	72 5.7	21 1.7	63 5	149 11.8	56 4.5	40 3.2	18 1.4
76-100 11-20	A* %	187 14.9	101 8	35 2.8	8 0.6	62 4.9	184 14.6	58 4.6	13 1	14 1.1
101-150 21-30	A* %	88 7	51 4.1	35 2.8	7 0.6	26 2.1	94 7.5	35 2.8	8 0.6	18 1.4
151-200 31-50	A* %	54 4.3	35 2.8	31 2.5	1 0.1	15 1.2	52 4.1	26 2.1	16 1.3	12 1
> 200 > 50	A* %	34 2.7	32 2.5	31 2.5	15 1.2	15 1.2	34 2.7	25 2	19 1.5	19 1.5
Discrepancy Analysis between Variables		X*X=86.85 P-value=0.0000				X*X=70.85 P-value=0.0000				

Table 8. Cross-Analysis Data of Perception of Crowdedness and Visitor Characteristics(Contd.)

Visitor Data / perception of Toler ance (per./ha per./km)		transportation						willingness to spend					
		public bus	private bus	tourist bus	taxi	autobike	bicycle, or foot	< 300 NT$	301-500	501-700	701-1000	1001-1500	> 1500
< 50	A*	28	80	23	2	47	7	88	43	15	19	7	15
< 6	%	2.2	6.4	1.8	0.2	3.7	0.6	7	3.4	1.2	1.5	0.6	1.2
51-75	A*	45	148	26	9	83	15	131	90	33	46	13	13
7-10	%	3.6	11.8	2.1	0.7	6.6	1.2	10.4	7.2	2.6	3.7	1	1
76-100	A*	39	180	18	9	74	11	103	72	45	67	23	21
11-20	%	3.1	14.3	1.4	0.7	5.9	0.9	8.2	5.7	3.6	5.3	1.8	1.7
101-150	A*	20	90	21	6	43	1	46	40	30	39	16	10
21-30	%	1.6	7.2	1.7	0.5	3.4	0.1	3.7	3.2	2.4	3.1	1.3	0.8
151-200	A*	20	62	10	0	26	3	52	17	17	19	5	11
31-50	%	1.6	4.9	0.8	0	2.1	0.2	4.1	1.4	1.4	1.5	0.4	0.9
> 200	A*	30	51	5	0	19	7	57	25	7	9	7	7
> 50	%	2.4	4.1	0.4	0	1.5	0.6	4.5	2	0.6	0.7	0.6	0.6
Discrepancy Analysis between Variables		X*X=51.63 P-value=0.0013						X*X=69.95 P-value=0.0000					

Table 9. Cross-Analysis Data of Visitor Attitudes and Perception of Crowdedness and Perception of Tolerance

		A		B		C		D		E		F		G	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II
Perception of Tolerance (persons/ha, persons/km)	< 50	64	17	22	6	5	3	13	6	19	8	4	3	10	7
	< 6	16	4.3	7.2	4.7	6.8	4.1	9.1	4.2	21.3	4.8	1.9	1.4	7.2	5
	51–75	62	30	67	11	25	5	21	9	42	5	50	19	45	5
	7–10	15.5	7.5	13.3	8.6	34.2	6.8	14.7	6.3	2.5	3	24.2	9.2	18	3.6
	76–100	20	24	20	7	3	0	14	13	33	8	78	26	31	4
	11–20	17.5	6	15.6	2.5	4.1	0	9.8	9.1	19.6	4.8	37.7	12.6	22.3	2.9
	101–150	47	26	11	5	4	0	12	11	22	6	10	12	13	1
	21–30	11.8	6.5	8.6	3.9	5.5	0	8.4	7.7	13.1	3.6	4.8	5.8	9.4	0.7
	151–200	32	14	8	4	6	3	7	5	17	5	3	2	10	5
	31–50	8	3.5	6.3	3.1	8.2	4.1	4.9	3.5	10.1	3	1.4	1	7.2	3.6
	> 200	9	4	13	4	10	9	20	12	3	0	0	0	16	12
	> 50	12.3	1	10.2	3.1	13.7	12.3	14	8.4	1.8	0	0	0	11.5	8.6
Difference Analysis, between Variables		X =5.29 P-value =0.3818		X =2.74 P-value =0.7396		X =8.76 P-value =0.0191		X =3.28 P-value =0.6655		X =5.12 P-value =0.4009		X =8.55 P-value =0.0735		X =14.81 P-value =0.0112	
Perception of Crowdedness (persons/ha, persons/km)	< 50	36	15	12	3	8	8	10	5	9	3	3	1	6	3
	< 6	9	3.8	9.4	2.3	11	11	7	3.5	5.4	1.8	1.4	0.5	4.3	2.2
	51–75	28	9	16	4	16	1	10	7	9	0	16	12	24	2
	7–10	2	2.3	12.5	3.1	21.9	1.4	7	4.9	5.4	0	7.7	5.8	17.3	1.4
	76–100	62	26	16	6	8	1	8	2	19	3	92	28	24	7
	11–20	5.5	6.5	12.5	4.2	11	1.4	5.6	2.1	11.2	1.8	64.4	13.5	9.3	5
	101–150	59	31	12	4	6	0	2	71	22	9	30	24	14	3
	21–30	14.8	7.8	10.2	3.1	8.2	0	4.9	4.9	13.1	5.4	14.5	6.8	10.1	2.2
	151–200	59	15	12	9	6	4	17	9	49	10	3	6	14	5
	31–50	14.8	3.8	9.4	7	8.2	5.5	11.9	6.2	29.2	6	1.4	2.9	10.1	3.6
	> 200	40	19	22	11	9	6	35	25	28	2	1	1	23	14
	> 50	10	4.8	17.2	8.6	12.3	8.2	24.5	7.5	16.7	4.2	0.5	0.5	16.3	10.1
	Difference Analysis between Variables	X =4.75 P-value =0.4472		X =3.92 P-value =0.5607		X =13.53 P-value =0.0189		X =1.97 P-value =0.8534		X =5.00 P-value =0.4153		X =11.01 P-value =0.0511		X =8.45 P-value =0.1333	

A = landscape observation

B = picnicking, barbecuing

C = camping

D = artificial amusement

E = physical training

F = temple visiting

G = mountain climbing

I = conserving

II = developing

Table 10. Cross-Analysis Data of Perception of Crowdedness and Perception of Tolerance

Perception of Tolerance (per./ha per./km) / Perception of Crowdedness (per./ha (per./km)	< 50 < 6 %		51-75 7-10 %		76-100 11-20 %		101-150 21-30 %		151-200 31-50 %		> 200 > 50 %	
< 50 < 6	83	6.6	44	3.5	28	2.2	16	1.3	7	0.6	9	0.7
51-75 7-10	22	1.7	97	7.7	153	10.7	25	2	32	2.5	15	1.2
76-100 11-20	7	0.6	7	0.6	118	9.4	125	9.9	51	4.1	23	1.8
101-150 21-30	2	0.2	2	0.2	8	0.6	41	3.3	76	6	52	4.1
151-200 31-50	5	0.4	2	0.2	11	0.9	8	0.6	44	3.5	51	4.1
> 200 > 50	3	0.2	2	0.2	3	0.2	4	0.3	9	0.7	91	7.2

X^2 = 1175.95 P-value = 0.0000
Pearcon's R = 0.66263

Table 11. Cross-Analysis Data of Holidays, Perception of Crowdedness and Perception of Tolerance

		< 50 < 6	%	51-75 7-10	%	76-100 11-20	%	101-150 21-30	%	151-200 31-50	%	> 200 > 50	%	Discrepany Analysis between varia-bles
Perception of Tolerance (persons/ha, persons/km)	Special Holiday	57	4.5	119	9.5	164	13	77	6.1	50	4	38	3	X*X=5.05
	Routine Holiday	48	3.8	117	9.3	103	8.2	67	5.3	39	3.1	38	3	P-value =0.0000
	Weekday	82	6.5	90	7.2	64	5.1	37	2.9	32	2.5	36	2.9	
Perception of Crowdedness (persons/ha, persons/km)	Special Holiday	32	2.5	48	3.8	115	9.1	123	9.8	94	7.5	93	7.4	X*X=11.83
	Routine Holiday	19	1.5	45	3.6	110	8.7	54	4.3	90	7.2	94	7.5	P-value =0.372
	Weekday	71	5.6	61	4.8	78	6.2	42	3.3	35	2.8	54	4.3	

Table 12. <u>Cross-Analysis Data of Recreation Activities and Spots with Perception of Crowdedness</u>

Recreation Activities	Rcreation Spots	< 50 < 6 A*	51-75 7-10 A*	76-100 11-20 A*	101-150 21-30 A*	151-200 31-50 A*	> 200 > 50 A*
landscape observation	Encore Garden Gate	44 20.7%	49 23.0%	59 27.7%	43 20.2%	13 6.1%	5 2.3%
	Inside of Encore Garden	37 19.8%	43 23.0%	35 18.7%	31 16.6%	33 17.6%	8 4.3%
picnicking barbecuing	Chung-cheng Camping Site	23 24.5%	18 19.1%	18 19.1%	9 9.6%	9 9.6%	17 18.1%
	Physical Training Field	5 14.7%	10 29.4%	9 26.5%	7 20.6%	3 8.8%	0 0
camping	Chung-cheng Camping Site	8 11.0%	30 41.1%	3 4.1%	4 5.5%	9 12.3%	19 26.0%
artificial amusement	Cartory Amusement Park	19 13.3%	30 21.0%	27 8.9%	23 16.1%	12 8.4%	32 22.4%
physical training	Physical Training Field	27 16.1%	47 28.0%	41 24.4%	28 16.7%	22 13.1%	3 1.8%
temple visiting	Sheng-shou Temple	7 3.4%	69 23.3%	104 50.2%	22 10.6%	5 2.4%	0 0
mountain climbing hiking	Mountain Climbing Footpath	17 12.2%	30 21.6%	35 25.2%	14 10.1%	15 10.8%	28 20.1%
Total		170 15.2%	296 26.5%	296 26.5%	167 14.9%	106 9.8%	84 7.5%

A* : (per./ha, per./km)

Table 13. Cross-Analysis Data of Recreation Activities and Spots with Perception of Tolerance

Recreation Activities	Rcreation Spots	< 50 < 6 A*	51-75 7-10 A*	76-100 11-20 A*	101-150 21-30 A*	151-200 31-50 A*	> 200 > 50 A*
landscape observa-tion	Encore Garden Gate	25 11.7%	18 8.5%	49 23.0%	52 24.4%	38 17.8%	31 14.6%
	Inside of Encore Garden	26 13.9%	19 10.2%	39 20.9%	38 20.3%	37 19.8%	28 15.0%
picnicking barbecuing	Chung-cheng Camping Site	15 16.0%	17 18.1%	19 20.2%	12 12.8%	11 11.7%	20 21.3%
	Physical Training Field	3 8.8%	3 8.8%	3 8.8%	5 14.7%	10 29.4%	13 38.2%
camping	Chung-cheng Camping Site	16 21.9%	17 23.3%	9 12.3%	16 8.2%	10 13.7%	15 20.5%
artificial amusement	Cartory Amusement Park	15 10.5%	17 11.9%	11 7.7%	14 9.8%	26 18.2%	60 48.0%
physical training	Physical Training Field	12 7.1%	9 5.4%	22 13.1%	31 18.5%	59 35.1%	35 20.8%
temple visiting	Sheng-shou Temple	4 1.9%	28 13.5%	120 58.0%	44 21.3%	9 4.3%	2 1.0%
mountain climbing hiking	Mountain Climbing Footpath	9 6.5%	26 18.7%	31 22.3%	17 12.2%	19 13.7%	37 26.6%
Total		113 10.1%	128 11.4%	272 24.3%	202 18.1%	200 17.9%	204 18.2%

A* : (per./ha, per./km)

Table 15. Data of Motive, Outcome and the Reason for Unwilling to Revisit

Survey Items	Survey Results		No.of interviewee	%	Accuminated number (%)
Motive	to be close to nature	Yes No	946 312	75.2 24.8	75.2 100.0
	to increase social activity oppor tunity	Yes No	149 1109	11.8 88.2	11.8 100.0
	physical training	Yes No	335 923	26.6 73.4	26.6 100.0
	to broaden knowledge	Yes No	218 1040	17.3 82.7	17.3 100.0
	to experience of change of pace	Yes No	872 386	69.3 30.7	69.3 100.0
Outcome	mental satisfaction	Yes No	479 779	38.1 61.9	38.1 100.0
	to increase knowledge	Yes No	102 1156	8.1 91.9	8.1 100.0
	to increase social activy opportunities	Yes No	144 1114	11.4 88.6	11.4 100.0
	relaxation	Yes No	1024 274	81.4 18.6	81.4 100.0
	natural beauty enjoyment	Yes No	404 854	32.0 68.0	32.0 100.0
Reason for Unwilling to Revisit	citing too many people	Yes No	66 144	31.4 68.6	31.4 100.0
	lack of landscape charac-teristics	Yes No	67 147	30.0 70.0	30.0 100.0
	too much in a mess	Yes No	37 173	17.6 82.4	17.6 100.0
	incovenient in transporta-tion	Yes No	41 169	19.5 80.5	19.5 100.0
	no time	Yes No	59 151	28.1 71.9	28.1 100.0
	not satisfied of their pur-pose to be here	Yes No	87 128	41.4 58.6	41.4 100.0

Table 14. Analysis Data of Satisfaction Degree and Willingness to Revisit

Survey Items	Survey Results	No.of interviewee	%	Accuminated number (%)
Satisfaction Degree	very satisfied	154	12.2	12.2
	satisfied	569	45.2	57.5
	at least some what satisfied	455	36.2	93.6
	unsatisfied	59	4.7	98.3
	very unsatisfied	21	1.7	100.0
Willingness to Revisit	willing	825	65.8	65.6
	unwilling	121	9.6	75.2
	not sure	312	24.8	100.0

Table 16. Analysis Data of Visitors' Satisfaction Degree, Number, Group Size and Willingness to Revisit

		Satisfaction Degree										
		very satis-fied	%	satis-fied	%	at least some what satisfied	%	unsa-tis-fied	%	very unsa-tis-fied	%	
No. of Person Visit	< 20 per.	38	3	89	7.1	50	4	7	0.6	0	0	
	21-50 "	33	2.6	87	6.9	65	5.2	8	0.6	14	1.1	X*X=101.07
	51-100 "	20	1.6	93	7.4	90	7.2	11	0.9	0	0	P-value
	101-300 "	47	3.7	222	17.6	193	15.3	25	2	2	0.2	=0.0000
	301-500 "	4	0.3	56	4.5	27	2.1	4	0.3	0	0	
	> 500 "	12	1	22	1.7	30	2.4	4	0.3	5	0.4	
Tourist Group Size	1-2 group	31	2.5	73	5.8	70	5.6	12	1	3	0.2	
	3-5 "	45	3.6	122	9.7	86	6.8	5	0.4	14	1.1	X*X=74.46
	6-10 "	30	2.4	118	9.4	110	8.8	19	1.5	3	0.2	P-value
	11-20 "	13	1	83	6.6	93	7.4	12	1	1	0.1	=0.0000
	> 20 "	35	2.8	172	13.7	96	7.6	11	0.9	0	0	
Willingness to Revisit	willing	149	11.8	472	37.5	197	15.7	6	0.5	1	0.1	X*X=485.6
	unwilling	2	0.2	14	1.1	59	4.7	33	2.6	13	1	P-value
	not sure	3	0.2	83	6.6	199	15.8	20	1.6	7	0.6	=0.0000

Table 17. Analysis Data of Visitors' Attitudes to the Future Development of Ta-keng Scenic Area

	Conservation		Development	
Landscape Observation	285	64.5%	115	35.5%
Picnicking & Barbecuing	81	68.6%	37	31.4%
Camping	53	72.6%	20	27.4%
Artificial Amusement	87	60.8%	56	39.2%
Physical Training	136	81.0%	32	19.0%
Temple Visiting	145	70.0%	62	30.0%
Mountain Climbing	195	75.5%	34	24.5%
Total	902	71.7%	356	28.3%

Appendix 8.4. The Momentary Number of Visitors and Visitor Groups Observations

Time	No. of Tourists (Person visit)	%	No. of Visitor Groups	%
5:00-5:30	2	-	1	0.02
5:30-6:00	44		8	
6:00-6:30	25		7	
6:30-7:00	30	0.46	9	1.11
7:00-7:30	35		10	
7:30-8:00	78		17	
8:00-8:30	1340		61	
8:30-9:00	1454	10.59	71	6.06
9:00-9:30	1989		146	
9:30-10:00	2530		209	
10:00-10:30	2876	18.46	259	16.49
10:30-11:00	2948		288	
11:00-11:30	3336		316	
11:30-12:00	3509	22.31	364	22.64
12:00-12:30	3254		358	
12:30-13:00	3514		313	
13:00-13:30	2408	16.33	281	19.15
13:30-14:00	2469		284	
14:00-14:30	2393		274	
14:30-15:00	2350	15.43	261	17.56
15:00-15:30	2241		270	
15:30-16:00	2788		268	
16:00-16:30	2442	16.37	266	16.90
16:30-17:00	2179		241	
17:00-17:30	20	0.05	3	0.07
Total	45254	100	4585	100

Appendix 8.5 Explanation of Affecting Factors and Subcriteria of the Analytic Hierarchy Process

Affecting Factor 1: Effects on the flora of the site

Due to trampling, plucking and carving, etc., tourists greatly affect plant growth and further act upon the landscape resources of the site. The degree of effect and tolerability are different depending on the physical nature of the plants. Therefore, the characteristics of the flora of the site and some subcriteria have to be considered as follows:

(1) Uniqueness

Uniqueness indicates the rareness of the species, scale and distribution of individuals within the plant community. Plant species tolerance also varies.

(2) Quantity and Density

The quantity and density of the plants will affect the coverage of the site. Their degree of vulnerability varies.

(3) Pristine Wilderness

Since the amount of artificial influence imposed upon the plant community is variable, their tolerability also varies.

Affecting Factor 2: Effects on the fauna of the site

Recreational activities affect animal habitats, which subsequently leads to change in animal population, including their composition. The degree of vulnerability is variable because of the differing characteristics of the animals at the site and their tolerance.

(1) Uniqueness

This indicates the rariety of species, scale and distribution of individuals within the animal population. Tolerability differs.

(2) Quantity and Density

The total number and density of each animal species also have differing effects caused by change.

(3) Type and Species

The various types and species of animals will affect animal migration and their degree of vulnerability.

(4) The Number of Species

This indicates the composition and diversity of the animal population, which affects the tolerance of the animal population as a whole.

Affecting Factor 3: Effects on the water resources of the site

Water resources are an important element in the physical ecological environment. Polluted water and wastes produced by each kind of activity seriously affects water quality.

(1) Distance of the site away from the water source

(2) Water quantity available to the site

(3) Polluted water collection and treatment at the site

(4) Site drainage conditions.

Affecting Factor 4: Effects on the natural landscape of the site

The natural landscape of a site includes the local features of the natural elements, such as vegetations, terrain, water bodies and plantations, etc. Its degree of vulnerability varies because of the differing amount of visitors and different kinds of activities.

(1) Pristine wilderness

The pristine wilderness of the natural landscape of a site has distinctive quality, including its visual amenity. The degree of being affected is different for different landscape structures.

(2) Continuity

The continuity of the natural landscape provides a sense of repetition and order, with a simple and uniform pattern that blends with the surroundings. Its degree of vulnerability varies in accordance with the structure of the landscape.

(3) Uniformity

The uniformity of the natural landscape of a site corresponds with and emphasises its original nature and coordinates with the surroundings. Its degree of vulnerability differs according to the different struture of landscape.

(4) Variability

The variability of the natural landscape of a site relates to its diversity. Its degree of vulnerability differs in accordance with the varying geomorphology of the natural landscape.

(5) Contents

The contents of the natural landscape of a site has its own characteristic qualities in terms of special meanings and aesthetic values. Its degree of vulnerability differs in accordance with all of the natural elements of the landscape.

(6) Visual Amenity

The natural landscape of a site generates varied scenic views. Its degree of vulnerability differs according to the morphology of the natural landscape.

Affecting Factor 5: Effects of wastes of the site on the Environmental sanitation

Almost every kind of recreational activity generates wastes. Whether the waste treatment at a recreation site is difficult or easy has a great effect on the environmental sanitation.

(1) Size of the site

(2) Waste treatment at the site

(3) Access to waste treatment facilities.

Affecting Factor 6: Effects on the special interests of the site

Physical ecological factors include natural, artificial, visible and invisible elements. Various compositions of factors generate the special interests of a site. These special interests are affected by the amount of visitors and their activities and behaviour.

(1) Local characteristics

The type and structure of a site generates its local characteristics. Their degree of vulnerability are also different.

(2) Regional landmark

Special features of a site can be identified as a regional landmark. Because their factor compositions are varied, their vulnerability to being effected also vary.

(3) Speciality

The special symbols of a site include points (such as monuments, towers), lines (footpaths, fences) and blocks (house gardens, water pools), shaped symbols and substantial sense and colour symbols. Their vulnerability to being affected also vary.

Affcting Factor 7: Effects on the topography of the site

The terrain of a site is composed of the changing relief, gradients, and slope aspects that generate special features. For the differing requirements for implementing various recreational activities, there are varying degrees of development and changes necessary to alter the original terrain.

(1) Pristine wilderness

(2) Variety

(3) Continuity.

Affecting Factor 8: Effects on the geology of the site

Because the natures of various kinds of recreational activities are varied, sites must have a certain degree of development. If earth excavation or earth filling is done, the geological stability will be damaged. The geological change differs according to the geological status.

(1) <u>Geological stability</u>

(2) <u>Soil erosion</u>

(3) <u>Soil water percolation</u>

(4) <u>Waste or artificial earth filling.</u>

Appendix 8.6 Analytic Hierarchy Process Survey Questionnaire

There are two parts included in the Analytic Hierarchy Process survey questionnaire for Ta-keng Scenic Area : One is the survey questionnaire in which a letter for experts and scholars and the questionnaire are listed ; the other is the execution of the survey in which detail information such as the qualification and selection of the experts and scholors, dispatching and collection of the questionnaire, etc. are described.

A. Survey questionnaire

A1. A letter for experts and scholars

Dear Sir or Madam; February 2, 1989

How are you ? This is a copy of a questionnaire about Taichung Ta-Keng Scenic Area Recreation Carrying Capacity. The main purpose is to ascertain the relative weight of each recreational activity which affects the analysis evaluation principles of the physical environment. For this, your professional knowledge is needed to help this undertaking. Your views will help this study to progress.

Sincerely yours,

Wang, Hsiao-Lin
Graduate School of
Architecture and
Urban Planning
Feng Chia University

A2. The questionnaire

A2.1 Introduction

The measurement method of the physical-ecological carrying capacity of the study uses the Analytic Hierarchy Process (AHP). This questionnaire is divided into two parts:

(1) Evaluation of the affecting degree of each recreational activity on the physical-ecological factors.

(2) Measurement of the maximum momentary physical-ecological carrying capacity acceptable for the recreational activities in Ta-Keng Scenic Area.

A2.2 Example and explanation

To answer this questionnaire, you mark an "X" in the space you think adequate according to your knowledge and experience. (All are single choice.)

For example, suppose you have two criteria in choosing your marriage partner: namely, internal beauty and external beauty. However, you think the importance of internal beauty is more "strong" when compared with external beauty. Then you would mark an "X" under the word "Strong" (as is shown in the following list).

Criteria	Strength																	Criteria
	9:1 Absolutely Strong	8:1 Very Strong - Absolutely Strong	7:1 Very Strong	6:1 Strong - Very Strong	5:1 Strong	4:1 A Little Strong - Strong	3:1 A Little Strong	2:1 Fairly Strong - A Little Strong	1:1 Fairly Strong	1:2 A Little Weak - Fairly Strong	1:3 A Little Weak	1:4 Weak - A Little Weak	1:5 Weak	1:6 Very Weak - Weak	1:7 Very Weak	1:8 Absolutely Weak - Very Weak	1:9 Absolutely Weak	
Internal Beauty					X													External Beauty

For the different activities and recreational spots of Ta-keng Scenic Area, the following eight categories are used in the questionnaire, but only "landscape observation" is explained as an example in this appendix.

Number of Categories	Activity Items	Recreational spots
1	Landscape Observation	Artificial Area, Encore Garden
2	Landscape Observation	Natural Area, Encore Garden
3	Landscape Observation	Mountain Ridges & River Valley Protection Area
4	Picnicking & Barbecuing	Chung-cheng Camping Site
5	Camping	Chung-cheng Camping Site
6	Physical Training	Physical Training Field
7	Temple Visiting	Sheng-shou Temple
8	Mountain Climbing	Mountain Climbing Footpath No.1

A2.3 The questionnaire

Activity Item: Landscape Observation

Place: Artificial, Encore Garden

Interviewee's Name: Mr. Y

A. The relative weight comparison of the landscape observation effects on physical ecological factors.

Special nature of the activity: Arrival at a certain specified place to enjoy natural or artificial landscape.

In order to understand the effect-weights of the landscape observation on the following eight physical-ecological factors, please evaluate their relative degree of vulnerability respectively and mark the results in Table 1.

1. Effect on plants
2. Effect on animals
3. Effect on water resources
4. Effect on natural landscape
5. Effect of wastes on environmental sanitation
6. Effect on special interests
7. Effect on the site terrain
8. Effect on the site geology.

B. Relative effect-weight comparison of subcriteria

a. For evaluating the effect-weights of the subcriteria

Table 1. Relative Weight Comparison of the Landscape Observation Effect on Physical Ecological Factors

Relative Effect-Weight / Site Affecting Factors	Strength: 9:1 Absolutely Strong	8:1 Very Strong - Absolutely Strong	7:1 Very Strong	6:1 Strong - Very Strong	5:1 Strong	4:1 A Little Strong - Strong	3:1 A Little Strong	2:1 Fairly Strong - A Little Strong	1:1 Fairly Strong	1:2 A Little Weak - Fairly Strong	1:3 A Little Weak	1:4 Weak - A Little Weak	1:5 Weak	1:6 Very Weak - Weak	1:7 Very Weak	1:8 Absolutely Weak - Very Weak	1:9 Absolutely Weak	Relative Effect-Weight / Site Affecting Factors
1 Effect on Plants																		2 Effect on Animals
1 Ditto																		3 Effect on Water Resources
1 Ditto																		4 Effect on Natural Landscape
1 Ditto																		5 Effect on Environmental Sanitation
1 Ditto																		6 Effect on Special Interests
1 Ditto																		7 Effect on Terrain
1 Ditto																		8 Effect on Geology
2 Effect on Animals																		3 Effect on Water Resources
2 Ditto																		4 Effect on Natural Landscape
2 Ditto																		5 Effect of Wastes on Environmental Sanitation
2 Ditto																		6 Effect on Special Interests
2 Ditto																		7 Effect on Terrain
2 Ditto																		8 Effect on Geology
3 Effect on Water Resources																		4 Effect on Natural Landscape
3 Ditto																		5 Effect of Wastes on Environmental Sanitation
3 Ditto																		6 Effect on Special Interests
3 Ditto																		7 Effect on Terrain
3 Ditto																		8 Effect on Geology
4 Effect on Natural Landscape																		5 Effect of the Wastes on Environmental Sanitation
4 Ditto																		6 Effect on Special Interests
4 Ditto																		7 Effect on Terrain
4 Ditto																		8 Effect on Geology
5 Effect of Wastes on Environmental Sanitation																		6 Effect on Special Interests
5 Ditto																		7 Effect on Terrain
5 Ditto																		8 Effect on Geology
6 Effect of Special Interests																		7 Effect on Terrain
6 Ditto																		8 Effect on Geology
7 Effect on Terrain																		8 Ditto

which affect the plants, please consider the following three subcriteria and, according to your views, mark the relative effect-weight in Table 2.

(1) Uniqueness

(2) Quantity and Density

(3) Pristine Wilderness.

Table 2. The Site Plant's Degree of Vulnerability in Subcriteria

Relative Effect-Weight / Site Sub-criterion	Strength																	Relative Effect-Weight / Site Sub-criterion
	9:1 Absolutely Strong	8:1 Very Strong - Absolutely Strong	7:1 Very Strong	6:1 Strong - Very Strong	5:1 Strong	4:1 A Little Strong - Strong	3:1 A Little Strong	2:1 Fairly Strong - A Little Strong	1:1 Fairly Strong	1:2 A Little Weak - Fairly Strong	1:3 A Little Weak	1:4 Weak - A Little Weak	1:5 Weak	1:6 Very Weak - Weak	1:7 Very Weak	1:8 Absolutely Weak - Very Weak	1:9 Absolutely Weak	
1 Uniqueness																		2 Quantity & Density
2 Quantity & Density																		3 Pristine Wilderness
3 Pristine Wilderness																		3 Pristine Wilderness

b. For evaluating the effect-weights in the subcriteria which affect the animals, please consider the following four subcriteria and, according to your views, mark the relative effect-weights in Table 3.

(1) Uniqueness

(2) Quantity and Density

(3) Types

(4) Number of Species.

c. For evaluating the effect-weight in the subcriteria which affect the water resources, please consider the following four subcriteria and, according to your views, mark the relative effect-weights in Table 4.

(1) Distance of the site from the water source

(2) Quantity of the site's potable water

(3) Collection and treatment of the site's polluted water

(4) Site drainage condition.

d. For evaluating the effect-weights in the subcriteria which affect the natural landscape, please consider the following six subcriteria and, according to your views, mark the relative effect-weights in Table 5.

(1) Pristine Wilderness

(2) Continuity

(3) Uniformity

(4) Variability

(5) Contents

Table 3. The Site Animals' Degree of Vulnerability in Subcriteria

Relative Effect-Weight / Site Sub-criterion	Strength: 9:1 Absolutely Strong; 8:1 Very Strong - Absolutely Strong; 7:1 Very Strong; 6:1 Strong - Very Strong; 5:1 Strong; 4:1 A Little Strong - Strong; 3:1 A Little Strong; 2:1 Fairly Strong - A Little Strong; 1:1 Fairly Strong; 1:2 A Little Weak - Fairly Strong; 1:3 A Little Weak; 1:4 Weak - A Little Weak; 1:5 Weak; 1:6 Very Weak - Weak; 1:7 Very Weak; 1:8 Absolutely Weak - Very Weak; 1:9 Absolutely Weak	Relative Effect-Weight / Site Sub-criterion
1 Uniqueness		2 Quantity & Density
1 Ditto		3 Types & Species
1 Ditto		4 No. of Species
2 Quantity & Density		3 Types & Species
2 Ditto		4 No. of Species
3 Types & Species		4 Ditto

Table 4. <u>Site Water Resources, Degree of Vulnerability in Subcriteria</u>

Relative Effect-Weight / Site Sub-criterion	Strength																	Relative Effect-Weight / Site Sub-criterion
	9:1 Absolutely Strong	8:1 Very Strong - Absolutely Strong	7:1 Very Strong	6:1 Strong - Very Strong	5:1 Strong	4:1 A Little Strong - Strong	3:1 A Little Strong	2:1 Fairly Strong - A Little Strong	1:1 Fairly Strong	1:2 A Little Weak - Fairly Strong	1:3 A Little Weak	1:4 Weak - A Little Weak	1:5 Weak	1:6 Very Weak - Weak	1:7 Very Weak	1:8 Absolutely Weak - Very Weak	1:9 Absolutely Weak	
1 Distance away from criterion																		2 Quantity of Potable Water
1 Ditto																		3 Polluted Water Collection & Treatment
1 Ditto																		4 Drainage Status
2 Quantity of Potable Water																		3 Polluted Water Collection & Treatment
2 Ditto																		4 Drainage Condition
3 Polluted Water Collection & Treatment																		4 Ditto

Table 5. Natural Landscape Degree of Vulnerability in Subcriteria

Relative Effect-Weight / Site Sub-criterion	Strength 9:1 Absolutely Strong 8:1 Very Strong - Absolutely Strong 7:1 Very Strong 6:1 Strong - Very Strong 5:1 Strong 4:1 A Little Strong - Strong 3:1 A Little Strong 2:1 Fairly Strong - A Little Strong 1:1 Fairly Strong 1:2 A Little Weak - Fairly Strong 1:3 A Little Weak 1:4 Weak - A Little Weak 1:5 Weak 1:6 Very Weak - Weak 1:7 Very Weak 1:8 Absolutely Weak - Very Weak 1:9 Absolutely Weak	Relative Effect-Weight / Site Sub-criterion
1 Pristine Wilderness		2 Continuity
1 Ditto		3 Uniformity
1 Ditto		4 Variability
1 Ditto		5 Contents
1 Ditto		6 Visual Amenity
2 Continuity		3 Uniformity
2 Ditto		4 Variability
2 Ditto		5 Contents
2 Ditto		6 Visual Amenity
3 Uniformity		4 Variability
3 Ditto		5 Contents
3 Ditto		6 Visual Amenity
4 Varia-bility		5 Contents
4 Ditto		6 Visual Amenity
5 Contens		6 Ditto

(6) Visual Amenity.

e. For evaluating the effect-weights in the subcriteria in which wastes affect the site environmental sanitation, please consider the following three subcriteria and, according to your views, mark the relative effect-weights in Table 6.

(1) Size of the site area

(2) Site waste treatment facilities situation

(3) Accessibility to site waste treatment facilities.

f. For evaluating the effect-weights in the subcriteria which affect the special interests, please consider the following three subcriteria and, according to your views, mark the relative effect-weights in Table 7.

(1) Local characterictics

(2) Regional landmark

(3) Regional speciality.

g. For evaluating the effect-weights in the subcriteria which affect the site terrain, please consider the following three subcriteria and, according to your views, mark the relative effect-weight in Table 8.

(1) Pristine wilderness

(2) Variability

(3) Continuity.

Table 6. <u>Wastes Affect On the Site Environmental Sanitation, of which the Degree of Vulnerability in the Subcriteria</u>

Relative Effect-Weight / Site Sub-criterion	Strength: 9:1 Absolutely Strong 8:1 Very Strong - Absolutely Strong 7:1 Very Strong 6:1 Strong - Very Strong 5:1 Strong 4:1 A Little Strong - Strong 3:1 A Little Strong 2:1 Fairly Strong - A Little Strong 1:1 Fairly Strong 1:2 A Little Weak - Fairly Strong 1:3 A Little Weak 1:4 Weak - A Little Weak 1:5 Weak 1:6 Very Weak - Weak 1:7 Very Weak 1:8 Absolutely Weak - Very Weak 1:9 Absolutely Weak	Relative Effect-Weight / Site Sub-criterion
1 Area Size		2 Waste Treatment Facilities Situation
1 Ditto		3 Accessibility to Waste Treatment Facilities
2 Waste Treatment Facilities Situation		3 Ditto

Table 7. Site Special Interest Degree of Vulnerability in Subcriteria

Relative Effect-Weight / Site Sub-criterion	Strength: 9:1 Absolutely Strong; 8:1 Very Strong - Absolutely Strong; 7:1 Very Strong; 6:1 Strong - Very Strong; 5:1 Strong; 4:1 A Little Strong - Strong; 3:1 A Little Strong; 2:1 Fairly Strong - A Little Strong; 1:1 Fairly Strong; 1:2 A Little Weak - Fairly Strong; 1:3 A Little Weak; 1:4 Weak - A Little Weak; 1:5 Weak; 1:6 Very Weak - Weak; 1:7 Very Weak; 1:8 Absolutely Weak - Very Weak; 1:9 Absolutely Weak	Relative Effect-Weight / Site Sub-criterion
1 Local Charac-teristics		2 Regional Landmark
1 Ditto		3 Regional Speciality
2 Regional Landmark		3 Ditto

Table 8. <u>Site Terrain Degree of Vulnerability in Subcriteria</u>

Relative Effect-Weight / Site Sub-criterion	Strength																	Relative Effect-Weight / Site Sub-criterion
	9:1 Absolutely Strong	8:1 Very Strong - Absolutely Strong	7:1 Very Strong	6:1 Strong - Very Strong	5:1 Strong	4:1 A Little Strong - Strong	3:1 A Little Strong	2:1 Fairly Strong - A Little Strong	1:1 Fairly Strong	1:2 A Little Weak - Fairly Strong	1:3 A Little Weak	1:4 Weak - A Little Weak	1:5 Weak	1:6 Very Weak - Weak	1:7 Very Weak	1:8 Absolutely Weak - Very Weak	1:9 Absolutely Weak	
1 Pristine wilderness																		2 Variability
1 Ditto																		3 Continuity
2 Variability																		3 Ditto

which affect the site geology, please consider the following four subcriteria and, according to your views, mark the relative effect-weights in Table 9.

(1) Geological stability

(2) Soil erosion

(3) Soil water percolation

(4) Wastes and artificial land reclamation on the site geology.

Table 9. Site Geological Degree of Vulnerability in the Subcriteria

Relative Effect-Weight / Site Sub-criterion	Strength: 9:1 Absolutely Strong; 8:1 Very Strong - Absolutely Strong; 7:1 Very Strong; 6:1 Strong - Very Strong; 5:1 Strong; 4:1 A Little Strong - Strong; 3:1 A Little Strong; 2:1 Fairly Strong - A Little Strong; 1:1 Fairly Strong; 1:2 A Little Weak - Fairly Strong; 1:3 A Little Weak; 1:4 Weak - A Little Weak; 1:5 Weak; 1:6 Very Weak - Weak; 1:7 Very Weak; 1:8 Absolutely Weak - Very Weak; 1:9 Absolutely Weak	Relative Effect-Weight / Site Sub-criterion
1 Geological Stability		2 Soil Erosion
1 Ditto		3 Soil Water Percolation
1 Ditto		4 Land Reclamation on Geology
2 Soil Erosion		3 Soil Water Percolation
2 Ditto		4 Waste & Artificial Land Reclamation on Geology
3 Soil Water Percolation		4 Ditto

c. According to your views, in terms of the tolerance of physical-ecological factor of the recreational sites of Ta-keng Scenic Area, the maximum momentary physical-ecological carrying capacity should be _____ m*m/person.

B. Execution of the survey

B1 Pilot test of questionnaires

The purpose of the pilot test of questionnaires is to simulate prior to formal distribution and to explore problems and make improvements. This study used fifteen students of the Graduate School of Architecture and Urban Planning of Feng Chia University as subjects of the pilot test. Emphasis was laid on how to answer the questionnaire, wording, and evaluation on the question items.

Fifteen questionnaires were distributed on January 15, 1989 and were all collected five days later. They were reviewed immediately. After necessary correction and revision of the contents, formal questionnaires were written and experts and scholars were arranged to answer the questionaires.

B2 Principles of selecting experts and scholars

Based on the purposes of study, the principles of selecting experts and scholars are as follows:

1. Those whose specialisation and background are related to the theme of this study;
2. Those whose teaching and research are related to the theme of this study;
3. Those whose publications and reports are related to the theme of this study;
4. Those who have comprehensive understanding of the project area of this study;

5. The experts and scholars who are likely to accept the invitation;
6. Those who are actually engaged in planning and management of recreation areas.

B3 Time and method of conduction of questionnaires

Formal conduction of the questionnaires stretched from February 1-28, 1989. All the questionnaires were distributed by the researcher herself. Twenty experts and scholars of nine diverse specialisations and background were invited to answer the questionnaires. The questionnaires were either collected by the researcher or returned by prompt delivery. Fifteen questionires were collected up to February 15. Five more were sent to the experts and scholars again by the researcher the following day. Altogether, thirty questionnaries were made but only twenty five were distributed. Twenty questionnaires were returned up to February 28. The rate of return is 100%.

Appendix 8.7. Relative Weight Analysis of Affecting Factors and Subcriteria -- landscape observation as an example

The following analysis is explained with the questionnaire of one of the experts:

1. The first hierarchical level (Part A of the questionnaire): relative weight of physical ecological affecting factors of the site.

Affecting factors:

(1) Effects on the flora of the site
(2) Effects on the fauna of the site
(3) Effects on the water resource of the site
(4) Effects on the natural landscape of the site
(5) Effects of wastes of the site on the environmental sanitation
(6) Effects on the special interests of the site
(7) Effects on the topography interests of the site
(8) Effects on the geology interests of the site.

The pairwise comparison matrix of the affecting factors is :

$$A = \begin{pmatrix} 1 & 5 & 6 & 0.333333 & 0.25 & 4 & 1 & 1 \\ 0.2 & 1 & 2 & 0.142857 & 0.133333 & 0.5 & 0.2 & 2 \\ 0.166666 & 0.5 & 1 & 7 & 8 & 0.5 & 0.25 & 0.13 \\ 3 & 7 & 0.142857 & 1 & 0.11111 & 0.5 & 0.2 & 1 \\ 4 & 8 & 0.133333 & 9 & 1 & 6 & 3 & 7 \\ 0.25 & 2 & 2 & 2 & 0.156666 & 1 & 3 & 0.25 \\ 1 & 5 & 4 & 5 & 0.333333 & 0.333333 & 1 & 4 \\ 1 & 0.5 & 8 & 1 & 0.142857 & 4 & 0.25 & 1 \end{pmatrix}$$

λ max = 8.614678

CI = 0.082811

RI = 0.062277

$$W = \begin{array}{c} (1) \\ (2) \\ (3) \\ (4) \\ (5) \\ (6) \\ (7) \\ (8) \end{array} \begin{pmatrix} 0.079540 \\ 0.056243 \\ 0.314042 \\ 0.314042 \\ 0.056243 \\ 0.032472 \\ 0.042736 \\ 0.104681 \end{pmatrix}$$

Affecting Factor	Relative Weight	order
(3)	0.314042	1
(4)	0.314042	1
(8)	0.104681	2
(1)	0.079540	3
(2)	0.056243	4
(5)	0.056243	4
(7)	0.042736	5
(6)	0.032972	6

2. The second hierarchical level (Part B of the questionnaire): relative weight of subcriteria of the site.

(1) Effects on the flora of the site: a. Unique

b. Quantity & Density

c. Pristine Wilderness

$$A = \begin{pmatrix} 1 & 7 & 2 \\ 0.142857 & 1 & 1 \\ 0.5 & 1 & 1 \end{pmatrix}$$

λmax = 3.001982

CI = 0.000991

RI = 0.001708

$$W = \begin{pmatrix} 0.082355 \\ 0.0315038 \\ 0.602601 \end{pmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.082355	2
(2)	0.0315038	3
(3)	0.602601	1

(2) Effects on the fauna of the site: a. Uniqueness

b. Quantity & Density

c. Type & Species

$$A = \begin{bmatrix} 1 & 0.5 & 3 & 0.25 \\ 2 & 1 & 3 & 6 \\ 0.333333 & 0.333333 & 1 & 0.333333 \\ 4 & 0.166666 & 3 & 1 \end{bmatrix}$$

$\lambda max = 4.060434$

$CI = 0.020144$

$RI = 0.022383$

$$W = \begin{bmatrix} 0.178264 \\ 0.211993 \\ 0.074951 \\ 0.534793 \end{bmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.178264	3
(2)	0.211993	2
(3)	0.074951	4
(4)	0.534793	1

(3) Effects on the water resource of the site: a. Distance

b. Quantity

c. Treatment

d. Drainage

$$A = \begin{bmatrix} 1 & 0.5 & 1 & 2 \\ 2 & 1 & 3 & 0.25 \\ 1 & 0.333333 & 1 & 0.333333 \\ 0.5 & 4 & 3 & 1 \end{bmatrix}$$

$\lambda max = 4.010356$

$CI = 0.003452$

$RI = 0.003836$

$$W = \begin{pmatrix} 0.351187 \\ 0.108939 \\ 0.188687 \\ 0.351187 \end{pmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.351187	1
(2)	0.108939	3
(3)	0.188687	2
(4)	0.351187	1

(4) Effects on the natural landscape: a. Pristine Wilderness
b. Continuity
c. Uniformity
d. Variability
e. Contents
f. Visual Amenity

$$A = \begin{pmatrix} 1 & 0.25 & 0.5 & 0.2 & 0.5 & 0.5 \\ 4 & 1 & 2 & 0.5 & 2 & 2 \\ 2 & 0.5 & 1 & 2 & 1 & 2 \\ 5 & 2 & 0.5 & 2 & 0.333333 & 1 \\ 2 & 0.5 & 1 & 3 & 1 & 3 \\ 2 & 0.5 & 0.5 & 1 & 0.333333 & 1 \end{pmatrix}$$

$\lambda\ max = 6.053957$

$CI = 0.003452$

$RI = 0.003836$

$$W = \begin{pmatrix} 0.353382 \\ 0.118012 \\ 0.079534 \\ 0.191065 \\ 0.066941 \\ 0.191065 \end{pmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.353382	1
(2)	0.118012	3
(3)	0.079534	4
(4)	0.191065	2
(5)	0.066941	5
(6)	0.191065	2

(5) Effects of wastes of the site on the environmental sanitation: a. Size

b. Treatment

c. Accessibility

$$A = \begin{bmatrix} 1 & 3 & 7 \\ 0.333333 & 1 & 0.5 \\ 0.142857 & 2 & 1 \end{bmatrix} \qquad \begin{aligned} \lambda\, max &= 0.121971 \\ CI &= 0.319625 \\ RI &= 0.558404 \end{aligned}$$

$$W = \begin{bmatrix} 0.121971 \\ 0.319625 \\ 0.558404 \end{bmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.121971	3
(2)	0.319625	2
(3)	0.558404	1

(6) Effects on the special interests of the site:

a. Local characteristics

b. Regional landmark

c. Regional characteristics

$$A = \begin{bmatrix} 1 & 0.333333 & 6 \\ 3 & 1 & 7 \\ 0.166666 & 0.142857 & 1 \end{bmatrix} \qquad \begin{aligned} \lambda\, max &= 3.021729 \\ CI &= 0.010865 \\ RI &= 0.018732 \end{aligned}$$

$$W = \begin{bmatrix} 0.330507 \\ 0.095094 \\ 0.574399 \end{bmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.330507	2
(2)	0.095094	3
(3)	0.574399	1

(7) Effects on the topography of the site:

a. Pristine Wilderness

b. Variety

c. Continuty

$$A = \begin{pmatrix} 1 & 1 & 0.5 \\ 1 & 1 & 3 \\ 2 & 0.333333 & 1 \end{pmatrix}$$

λ max = 3.018295

CI = 0.009147

RI = 0.015771

$$W = \begin{pmatrix} 0.209855 \\ 0.549924 \\ 0.240221 \end{pmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.209855	3
(2)	0.549924	1
(3)	0.240221	2

(8) Effects on the geology of the site: a. Stability

b. Soil Erosion

c. Percolation

d. Earth Filling

$$A = \begin{pmatrix} 1 & 5 & 3 & 2 \\ 0.2 & 1 & 1 & 0.5 \\ 0.333333 & 1 & 1 & 5 \\ 0.5 & 2 & 0.2 & 1 \end{pmatrix}$$

λ max = 4.004157

CI = 0.001386

RI = 0.001540

$$W = \begin{pmatrix} 0.081901 \\ 0.234755 \\ 0.448590 \\ 0.234755 \end{pmatrix}$$

Affecting Factors	Relative Weight	Order
(1)	0.087901	3
(2)	0.234755	2
(3)	0.448590	1
(4)	0.234755	2

3. Test of the consistency of the comparison matrix.

According to both the Oak Ridge National Laboratory and Warton School, a consistory index is made in a random way. (This index is called Random Index, R.I.). It is concerned with the level members of a matrix. The consistency ration is found

$$\text{C.R.} = \frac{\text{C.I.}}{\text{R.I.}}$$ If C.R. < 0.1, then the test is acceptable.

(1) C.I. of the first hierarchical level C.I.I. = 8.7811006E-0.2

R.I. of the first hierarchical level R.I.I. = 1.41

W : 0.079540, 0.056243, 0.314042, 0.314042,

0.056243, 0.032472, 0.042736, 0.104681

(2) C.I. of the second hierarchical level to the first hierarchical level:

0.000991, 0.020144, 0.003452, 0.010791,

0.009147, 0.010865, 1.486095, 0.005163.

(3) R.I. of the second hierarchical level to the first hierarchical level:

0.580000, 0.900000, 0.900000, 1.240000,

0.580000, 0.580000, 0.580000, 0.90000.

(4) C.I. and R.I. of the second hierarchical level:

C.I.2 = 7.060193E-02 R.I.2 = 3.411492

C.I.H = 0.158413

R.I.H = 4.821492

C.R.H = 0.0328556 < 0.1 acceptable.

(4) C.I. and R.I. of the second hierarchical level:

C.I.2 = 7.060193E-02 R.I.2 = 3.411492

C.I.H = 0.158413

R.I.H = 4.821492

C.R.H = 0.0328556 < 0.1 acceptable.

Appendix 9.1 Cost Estimation of Construction Works

Zone	Sub-Zone	Items	Quantity	Unit	Unit-Price (N.T.$)	Total Cost (N.T.$)	Remarks
X1	X1,1	Preservation Area					
		Footpath	400	m*m	400	160000	
		Car Park	50	m*m	350	17500	
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				202500	
	X1,2	Physical Training Field					
		Land Aquisition & Legal Fee	243400	m*m	100	24340000	
		Land Modelling	1423	m*m	55	78265	5%
		Road Construction	1423	m*m	500	711500	5%
		Landscaping	11383	m*m	300	3414900	40%
		Service Centre	285	m*m	8000	2280000	1%
		Footpath	4269	m*m	400	1707600	15%
		Car Park	285	m*m	350	99750	1%
		Public Lavatory	143	m*m	4200	600600	0.5%
		Physical Training Equipment	10	set	100000	1000000	
		Wastes Treatment			100000	100000	
		Total				34332615	
	X1,3	Camping Site					
		Land Aquisition & Legal Fee	507300	m*m	100	50730000	
		Land Modelling	3159	m*m	55	173745	5%
		Road Construction	3159	m*m	500	1579500	5%
		Landscaping	25269	m*m	300	7580700	40%
		Service Centre	632	m*m	8000	505600	1%
		Footpath	9476	m*m	400	3790400	15%
		Car Park	632	m*m	350	221200	1%
		Public Lavatory	316	m*m	4200	1327200	0.5%
		Public Bath	1	set	800000	800000	
		Camping Tents	90	set	3500	315000	
		Barbecue Sets	90	set	2500	225000	
		Drinking Fountain	45	set	4000	180000	
		Sewerage Treatment	45	set	2000	90000	
		Wastes Treatment			100000	100000	
		Total				67618345	
	X1,4	Picnicking & Barbecuing Site					
		Land Aquisition & Legal Fee	318300	m*m	100	31830000	
		Land Modelling	1361	m*m	55	74855	5%
		Road Construction	1361	m*m	300	408300	5%
		Landscaping	10891	m*m	500	5445500	40%
		Service Centre	272	m*m	8000	2176000	1%
		Footpath	4084	m*m	400	1633600	15%
		Car Park	272	m*m	350	95200	1%
		Barbecue Set	20	set	10000	200000	
		Drinking Fountain	10	set	4000	40000	
		Sewerage Treatment	10	set	2000	20000	
		Wastes Treatment			100000	100000	
		Total				42023455	
	X1,5	Mountain Climbing Footpath					
		Land Aquisition & Legal Fee	34750	m*m	80	2780000	
		Footpath	9000	m*m	400	3600000	
		Car Park	174	m*m	350	60900	0.5%
		Public Lavatory	35	m*m	4200	147000	0.1%
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				6612900	

Appendix 9.1 <u>Cost Estimation of Construction Works (contd.)</u>

Zone	Sub-Zone	Items	Quantity	Unit	Unit-Price (N.T.$)	Total Cost (N.T.$)	Remarks
X2	X2,1	Preservation Area					
		Footpath	800	m*m	400	320000	
		Car Park	100	m*m	350	35000	
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				380000	
	X2,2	Physical Training Field					
		Land Modelling	3759	m*m	55	206745	5%
		Road Construction	3759	m*m	500	9021000	40%
		Landscaping	30070	m*m	300	1978500	5%
		Service Centre	752	m*m	8000	6016000	1%
		Footpath	11276	m*m	350	3946600	15%
		Car Park	752	m*m	400	300800	1%
		Public Lavatory	376	m*m	4200	1579200	0.05%
		Physical Training Equipment	10	set	100000	1000000	
		Wastes Treatment			100000	100000	
		Total				24148845	
	X2,3	Camping Site					
		Land Modelling	1669	m*m	55	91795	5%
		Road Construction	1669	m*m	500	834500	5%
		Landscaping	13352	m*m	300	4005600	40%
		Service Centre	334	m*m	8000	2672000	1%
		Footpath	5007	m*m	400	20028000	15%
		Car Park	334	m*m	350	116900	1%
		Public Lavatory	167	m*m	4200	701400	0.5%
		Public Bath	1	set	800000	800000	
		Camping Tents	80	set	3500	280000	
		Barbecue Set	80	set	2500	200000	
		Drinking Fountain	40	set	4000	160000	
		Sewerage Treatment	40	set	2000	80000	
		Wastes Treatment			100000	100000	
		Total				12044995	
	X2,4	Picnicking & Barbecuing Site					
		Land Modelling	2017	m*m	55	110935	5%
		Road Construction	2017	m*m	300	605100	5%
		Landscaping	16138	m*m	500	8069000	40%
		Service Centre	403	m*m	8000	3224000	1%
		Footpath	6052	m*m	400	2420800	15%
		Car Park	403	m*m	350	141050	1%
		Barbecue Set	24	set	10000	240000	
		Drinking Fountain	12	set	4000	48000	
		Sewerage Treatment	12	set	2000	24000	
		Wastes Treatment			100000	100000	
		Total				14982885	
	X2,5	Mountain.Climbing Footpath					
		Footpath	47187	m*m	400	18874800	
		Car Park	472	m*m	350	165200	1%
		Public Lavatory	236	m*m	4200	991200	0.05%
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				20056200	

Appendix 9.1 Cost Estimation of Construction Works (contd.)

Zone	Sub-Zone	Items	Quantity	Unit	Unit-Price (N.T.$)	Total Cost (N.T.$)	Remarks
X3	X3,1	Preservation Area					
		Footpath	800	m*m	400	320000	
		Car Park	100	m*m	350	35000	
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				380000	
	X3,2	Physical Training Field					
		Land Aquisition & Legal Fee	69300	m*m	100	46930000	
		Land Modelling	1090	m*m	55	59950	5%
		Road Construction	1090	m*m	500	545000	5%
		Landscaping	8720	m*m	300	2616000	40%
		Service Centre	218	m*m	8000	1744000	1%
		Footpath	3270	m*m	400	1308000	15%
		Car Park	218	m*m	350	76300	1%
		Public Lavatory	45	m*m	4200	189000	0.02%
		Physical Training Equipment	15	set	100000	1500000	
		Wastes Treatment			100000	100000	
		Total				55068250	
	X3,4	Picnicking & Barbecuing Site					
		Land Aquisition & Legal Fee	165500	m*m	100	16550000	
		Land Modelling	730	m*m	55	40150	
		Road Construction	330	m*m	300	219000	
		Landscaping	5624	m*m	500	2812000	
		Service Centre	146	m*m	8000	1168000	
		Footpath	2190	m*m	400	876000	
		Car Park	146	m*m	350	51100	
		Barbecue Set	4	set	10000	40000	
		Drinking Fountain	2	set	4000	8000	
		Sewerage Treatment	2	set	2000	4000	
		Wastes Treatment			100000	100000	
		Total				2868250	
	X3,5	Mountain Climbing Footpath					
		Land Aquisition & Legal Fee	124000	m*m	100	12400000	
		Footpath	6250	m*m	400	2500000	
		Car Park	63	m*m	350	22050	1%
		Public Lavatory	32	m*m	420	134400	0.05%
		Interpretation Failities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				15081450	
	X3,6	Tourist Orchard Area					
		Land Aquisition & Legal Fee	721500	m*m	100	72150000	
		Road Construction	4733	m*m	500	2366500	6%
		Service Centre	789	m*m	8200	6312000	1%
		Footpath	11833	m*m	55	650815	15%
		Car Park	789	m*m	300	236700	1%
		Public Lavotory	79	m*m	350	27650	0.1%
		Wastes Treatment			15000	15000	
		Total				81716015	
	X3,7	Horse Riding Field					
		Land Aquisition & Legal Fee	431700	m*m	100	43170000	
		Road Construction	10154	m*m	500	5077000	
		Landscaping	18463	m*m	300	5538900	
		Administration Office	9231	m*m	3950	36462450	
		Stable	16616	m*m	650	10800400	
		Indoor Horse Riding Field	7385	m*m	2470	18240950	
		Horse Training Field	44310	m*m	148	6557880	
		Pasture	65542	m*m	31	2031802	
		Car Park	7385	m*m	350	2584750	
		Recreation Area	7385	m*m	1150	8492750	
		Tourist Centre	2769	m*m	3100	8583900	
		Wastes Treatment			100000	100000	
		Total				147640782	
	X3,8	Grass Skiing Field					
		Land Aquisition & Legal Fee	374000	m*m	100	37400000	
		Land Modelling	42027	m*m	55	2311485	40%
		Road Construction	5253	m*m	500	2626500	5%
		Landscaping	63040	m*m	300	18912000	60%
		Service Centre	1051	m*m	8000	8408000	1%
		Car Park	1051	m*m	350	367850	1%
		Public Lavatory	105	m*m	4200	441000	0.1%
		Wastes Treatment			100000	100000	
		Total				70566835	

Appendix 9.1 Cost Estimation of Construction Works (contd.)

Zone	Sub-Zone	Items	Quantity	Unit	Unit-Price (N.T.$)	Total Cost (N.T.$)	Remarks
X4	X4,1	Forestry Preservation Area					
		Footpath	800	m*m	400	320000	
		Car Park	100	m*m	350	35000	
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				380000	
	X4,5	Mountain Climbing Footpath					
		Footpath	21500	m*m	400	8600000	
		Car Park	215	m*m	350	75250	1%
		Public Lavatory	22	m*m	4200	92400	0.01%
		Interpretation Facilities	1	set	15000	15000	
		Liter Bins	1	set	10000	10000	
		Total				8694650	
X5	X5,1	Farmscape Preservation Area					
		Footpath	800	m*m	400	320000	
		Car Park	100	m*m	350	35000	
		Interpretation Facilities	1	set	15000	15000	
		Litter Bins	1	set	10000	10000	
		Total				380000	
X7	X7,4	Picnicking & Barbecuing Site					
		Land Aquisition & Legal Fee	125600	m*m	1000	125600000	
		Land Modelling	2250	m*m	55	123750	5%
		Road Construction	2250	m*m	300	675000	5%
		Landscaping	18000	m*m	500	9000000	40%
		Service Centre	450	m*m	8000	3600000	1%
		Footpath	6750	m*m	400	2700000	15%
		Public Lavatory	45	m*m	4200	189000	0.1%
		Car Park	450		350	157500	1%
		Barbacue Set	20		10000	200000	
		Drinking Fountain	10		4000	40000	
		Sewerage Treatment	10		2000	20000	
		Wastes Treatment			100000	100000	
		Total				142410250	
	X7,6	Tourist Orchard Area					
		Land Aquisition & Legal Fee	67100	m*m	1000	67100000	
		Footpath	2833	m*m	55	155815	15%
		Car Park	189	m*m	300	56700	1%
		Road Construction	1133	m*m	500	566500	6%
		Service Centre	189	m*m	8000	1512000	1%
		Public Lavatory	20	m*m	350	7000	0.1%
		Wastes Treatment	1	set	15000	15000	
		Total				69413015	
	X7,8	Grass Skiing Field					
		Land Aquisition & Legal Fee	81000	m*m	100	8100000	
		Land Modelling	21837	m*m	55	1201035	40%
		Road Construction	2730	m*m	500	1365000	5%
		Landscaping	32755	m*m	300	9826500	60%
		Service Centre	546	m*m	8000	4368000	1%
		Car Park	546	m*m	350	191100	1%
		Public Lavatory	55	m*m	4200	231000	0.01%
		Wastes Treatment			100000	100000	
		Total				25382635	

Appendix 9.1 <u>Cost Estimation of Construction Works (contd.)</u>

Zone	Sub-Zone	Items	Quantity	Unit	Unit-Price (N.T.$)	Total Cost (N.T.$)	Remarks
		Landscaping	32755	m*m	300	9826500	60%
		Service Centre	546	m*m	8000	4368000	1%
		Car Park	546	m*m	350	191100	1%
		Public Lavatory	55	m*m	4200	231000	0.01%
		Wastes Treatment			100000	100000	
		Total				25382635	
	X7,13	Mechanical Play Equipment Area					
		Land Aquisition & Legal Fee	161000	m*m	1500	241500000	
		Land Modelling	20983	m*m	55	1154065	20%
		Road Construction	15737	m*m	500	7868500	15%
		Landscaping	77500	m*m	300	23250000	50%
		Service Centre	1049	m*m	8000	8392000	1%
		Footpath	20983	m*m	400	8993200	15%
		Car Park	1049	m*m	350	367150	.1%
		Public Lavatory	105	m*m	4200	441000	0.1%
		Sitting Area	10491	m*m	1000	10491000	10%
		Recreation Area	41964	set	1500	62946000	40%
		Sewerage Treatment	1	set	150000	150000	
		Wastes Treatment			150000	150000	
		Total				364702915	
	X7,14	Tourist Centre Area					
		Land Aquisition & Legal Fee	73600	m*m	1500	110400000	
		Land Modelling	7146	m*m	55	393030	50%
		Road Construction	2144	m*m	500	3573000	15%
		Landscaping	7146	m*m	300	2143800	50%
		Structure Engineering	2858	m*m	3000	8574000	20%
		Finishing	2858	m*m	800	2286400	20%
		Water & Electricity Facilities	4858	m*m	200	971600	20%
		Car Park	1429	m*m	350	500150	10%
		Public Lavatory	72	m*m	4200	302400	0.5%
		Plaza	1429	m*m	500	714500	10%
		Interpretation Facilities	1	set	100000	100000	
		Wastes Treatment			150000	150000	
		Total				13018880	
	X7,15	Garden					
		Land Aquisition & Legal Fee	132600	m*m	1200	159120000	
		Land Modelling	2517	m*m	55	138435	5%
		Road Construction	20137	m*m	300	6041100	40%
		Landscaping	2517	m*m	500	1258500	5%
		Service Centre	503	m*m	8000	4024000	1%
		Footpath	7751	m*m	350	2712850	15%
		Car Park	503	m*m	400	201200	1%
		Public Lavatory	50	m*m	4200	210000	0.1%
		Wastes Treatment			15000	15000	
		Total				173721085	
X8	X8,16	Relics & Temples Area					
		Land Aquisition & Legal Fee	60000	m*m	1500	90000000	
		Land Modelling	22073	m*m	55	1214015	50%
		Road Construction	6622	m*m	500	3311000	15%
		Landscaping	22073	m*m	300	6621900	50%
		Structure Engineering	8829	m*m	3000	26487000	20%
		Finishing	8829	m*m	800	7063200	20%
		Water & Electricity Facilities	8829	m*m	200	1765800	20%
		Car Park	441	m*m	350	154350	1%
		Public Lavatory	44	m*m	4200	184800	0.1%
		Plaza	4415	m*m	500	2207500	10%
		Interpretation Facilities	1	set	100000	100000	
		Wastes Treatment			150000	150000	
		Total				139359565	
	X8,17	Forklore Activity Area					
		Land Aquisition & Legal Fee	90000	m*m	1500	135000000	
		Road Construction	5799	m*m	500	2899500	15%
		Land Modelling	19329	m*m	55	1063093	50%
		Landscaping	19329	m*m	300	5798700	50%
		Car Park	387	m*m	350	135450	0.1%
		Public Lavatory	39	m*m	4200	163800	0.1%
		Plaza	3866	m*m	500	1933000	10%
		Interpretation Facilities	1	set	100000	100000	
		Wastes Treatment			150000	150000	
		Total				147243445	

BIBLIOGRAPY

1. Aelman, B. J., et al., : "Social-Psychological Explanation for the Persistence of a Conflict between Paddling Canoeists and Motorcraft Users in the Boundry Waters Canoe Area". Leisure Science, Tayley & Francis, Washington D.C., U.S.A., 1982, 5:42-62.

2. Ahlfeld, D. P., et al., : "Contaminated Groundwater Remediation Decision Using Simulation, Optimization, and Sensitivity Theory". Water Resources Research, Vol. 24, No. 3, American Geophysical Union, Washington, D.C., U.S.A., 1988, pp. 443-452.

3. Agricuture College, National Taiwan University. "A Detailed Plan Instruction of Ta-Keng Scenic Area of Taichung City". (in Chinese), A Report to Taichung City Government, Taichung, Taiwan, ROC, 1985, p. 8.

4. Antle, L. G. : "Recreation at the McClelan-Kerr Arkansas River Navigation System". Water Resources Bulletin, Vol. 15, No. 5, American Water Resources Association, Bethesda, U.S.A., 1979.

5. Apps, P. F. : "Urban Design and the Problem of Evaluation, Social Services in Architecture". Architectural Service Research Unit, Syndey Univ., Australia, 1972.

7. Barber, G. M. : "Land-use Plan Design via Interaction Multiple Objective Programming", Environment and Planning A. Vol. 8, Pion Ltd., London U.K., 1976, pp. 625-636.

8. Bazaraa, M. S. and A. Bouzaher, : "A Linear Goal Programming Model for Developing Economics with an Illustration from the Agricultural Sector in Egypt". Management Science, Vol. 27, No. 4, The Institute of Management Science, Providence, U.S.A., April 1981, pp. 396-413.

9. Benayoun, J. De M., Tergny, J. and O. Larichev : "Linear Programming with Multiple Objective Functions : Step Method (STEM), Mathematical Programming, 1". 1971, pp. 366-375.

10. Berger, J. : "Guidelines for Landscape Synthesis : Some Directions-Old and New". Landscape and Urban Planning, Vol. 14, No. 4, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1987, pp. 295-311.

11. Bitran, G. R. : "Linear Multiple Objective Problems with Integral Coefficients". Management Science, Vol. 26, No. 7, The Institute of Management Science, Providence, U.S.A., July 1980, pp. 694-706.

12. Bitran, G. R. : "Linear Multiple-Objective Programs with Zero-one Variables". Mathematical Programming, Vol. 13, The Mathematical Programming Society, Inc., The Netherlands, 1977, pp. 121-139.

13. Boventer, E. V., Drewett, J.R., Koll R. & U. Schubert : "Urban Europe : Innovation and Urban Change. The Role of Social and Technological Change". Gower Publishing, Aldershot, (Ed.) 1987.

14. Brotherton, I. : "Determinants of Landscape Change : The Case Of Afforestation in the National Parks of England and Wales". Landscape Planning, Vol. 9, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1983, pp. 193-207.

15. Brotherton I. : "Development Pressures and Control in the National Parks". Town Planning Review, Vol. 53, No. 4, Liverpool Univ. Press, England, October 1982, pp. 439-459.

16. Brown, P. J. : "Planning for the Use of Recreation Resources". Intern. Sym. on Landscape and Recreational Planning, Taipei, R.O.C., 1985.

17. Buchwald, K. : "Aims and Methods of Ecological Planning : Strategies for the Realisation of an Optimal Combination of Land-Uses". Nanyang Univ., Singapore Symposium on "Our Environment". Singapore, 1978.

18. Bunka, K. : "Ecological Planning : Its Method and Application". 1975, pp. 48-164.

19. Bultena, G. L., et al., : "Closing the Gates : A Study of Backcountry Use-Limitation at Mount McKinley National Park". Leisure Science, Tayloy & Francis,

Washington, D.C., U.S.A., 1981, 4:249-267.

20. Carlson, C., et al., : "A Path for the Palouse : An Example of Conservation and Recreation Planning". Landscape and Urban Planning, Vol. 17, No. 1, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1989, pp. 1-19.

21. Chang, Feng Hsu : "Nature Conservation Letter". (in Chinese), Information Letter of Society for world and Nature, Taipei, ROC, December. 31, 1986, p. 6.

22. Chang, Kin yang : "Finance". (in Chinese), Wu Nan Publisher Company Limited, Taipei, ROC, 1976, pp. 175-176.

23. Chang, Tang : " Public Participation and Integrated Planning". (in Chinese), Planners, Taipei, ROC, No. 8, 1981, pp. 79-80.

24. Chapin, F. S. : "Human Activity Pattern in the City". John, wiley & Sons, Inc., U.S.A., 1981.

25. Chapman, H. : "The Machinery of Conservation". Town Planning Review, Vol. 46, No. 4, Livepool Univ. Press, England, October 1975, pp. 365-382.

26. Charnes, A. and W. W. Cooper : "Goal Programming and Multiple Objective Optimization-part 1". European Journal of Operational Research, Vol. 1, No. 1, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1977, pp. 39-54.

27. Checkland, P. : "From Optimizing to Learning : A Development of Systems Thinking for the 1990S". J. of the Operational Research Society, Vol. 36, No. 9, The Operational Research Society Limited, Birmingham, U.K., 1985, pp. 757-767.

28. Chen, Ching Hsing : "The Analysis Report, of Taiwan District Civilian Tourism Status Survey".(in Chinese), Tourism Information, Taipei, ROC, October. 10, 1982, p. 37.

29. Chen, Chu Wu : "An Introduction of an Ecological

Planning and Design Mehtod". Bulletin of Environmental Studies, Vol. 1, No. 1, National Taiwan Univ., Taipei, ROC, 1981, p. 143.

30. Chen, Se Ming : "Profit Theory Research". (in Chinese), Unpublished MSc thesis, Graduate School of Economy, Tung Wu Univ., Taipei, ROC, 1977. Chapter II.

31. Chen, Shui Yuas : "Research Report on Problems and Feasible Methods of Development of Tourism and Recreation Area in Taiwan". (in Chinese), Tourism Bureau of the Department of Communications, Taipei, ROC, 1984.

32. Chen, Shui Yuan : "Study on Relationships between Recreation Experiences and Evnironmental Factors". (in Chinese), Unpublished PhD thesis, Forestry Graduate School, National Taiwan Univ., Taipei, ROC, 1987, p. 2-23--3-3.

33. Chu, Ta Jung : "Management of Tourism Business in Tourism and Recreation". (in Chinese), J. of Chinese Transportation Society, Taipei, ROC, September 1977, pp. 16-17.

34. Chubb, M., and P. Ashton : "Park and Recreation". College of Agr. and Nat. Res., Michigan State Univ. Tech. Rep., No. 15, 1969, p. 76.

35. Chuo, Win Yen : "A Study of Land-Use Plan Design Model for New Towns". (in Chinese), Unpublished MSc thesis, Chung Hsing Univ., Taipei, ROC,1980, p. 35.

36. Clark, R. N., et al., : "The Recreation Opportunity Spectrum : A Framework for Planning, Management and Research". USDA Gen. Tech. Rep. PNW-98, U.S.A., December. 1979.

37. Cole, D., and J. Benedict : "Wilderness Campsite Selection : What Should Users Be Told ? "Park Science, Vol. 3, No. 4, 1983, pp.5-7.

38. Cook, W. D. : "Goal Programming and Financial Planning Models for Highway Rehabilitation". J. of the Operational Research Society, Vol. 35, No. 3, The Operational Reserch Siciety Limited, Birmingham, U.K.

1984, pp. 217-223.

39. Dearden, P. : "Factors Influcing Landscape Perferences : An Empirical Investigation". Landscape Planning, Vol. 11, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1984, pp. 293-306.

40. Dennier, D. A. : "National Park Plans". Town Planning Review, Vol. 49, No. 2, Liverpool Univ. Press, England, April 1978, pp. 175-183.

41. Drewett, J. R. : "A Stochastic Model of the Land Conversion Process-An Interim Report". Regional Studies, Vol. 3, Carfax Publishing Company, Oxfordshire, U.K., 1969, pp. 269-280.

42. Drewett, J. R. : "Changing Urban Structures in Europe". Annuals of the American Academy of Political and Social Science, Phil. Vol. 451, U.S.A., 1980.

43. Driver, B. L. and S. R. Tocher : "Toward a Behavioural Interpretation of Recreational Engagement with Implications for Planning". In Elements of Outdoor Recreation Planning, B.L. Driver(Ed.), Univ. of Michigan, Ann Arbor, Michigan, 1970.

44. Duckstein, L. and S. Opricovic : "Multi-objective Optimization in River Basin Development". Water Resources Research, Vol. 16, No. 1, American Geophysical Union, Washington, D.C., 1980, pp. 14-20.

45. Duesing, Erick C. : "Multiple Objective Linear Programming and the Theory of the Firm, I. Substitution and Sensitivity Analysis". Lecture Notes in Econom. and Math. Systems, 209, Springer, Berlin-New york, 1983.

46. Dyer, J. S. and R. K. Sarin : "Group Preference Aggregation Rules Based on Strength of Preference". Management Science, Vol. 25, No. 9, The institute of Management Science, Providence, U.S.A., September., 1979.

47. Dyson, R. G. : "Maximum Programming, Fuzzy Linear Programming and Multi-Criteria Decision Making". J.

of the Operational Research Society, 31, The Operational Research Society Limited, Birmingham, U.K., 1980, pp. 263-367.

48. Evans, G. W. : "An Overview of Techniques for Solving Multiobjective Mathematical Programs". Management Science, Vol. 31, No. 11, The institute of Management Science, Providence, U.S.A., 1984, pp. 1268-1282.

49. Ecker, J. G., et al., : "Generating All Maximal Efficient Faces for Multiple Objective Linear Program". J. of Optimization Theory and Applications, Vol. 30, No. 3, Plenum Publishing Corporation, Bristol, U.K., March 1980.

50. Council for Economic Planning and Development, Executive Yuan : "Sight-seeing and Recreation System of Taiwan Area".(in Chinese), Taipei, ROC, 1983, p. 136.

51. Fandel, Gunter and Tomash Gal. (ed.) : "Multiple Criteria Decision Making, Theory and Application". Lecture Notes in Economics and Mathematical Systems, 177. Proceedings of the Third Conference held at Hagen/Konigswinter, August 20-24, 1979.

52. Fisher, A. C. and J. V. Krutilla : "Determination of Optimal Capacity of Resource-based Recreation Facilities". Natural Resource Journal, 12:417-444, School of Law, Univ. of New Mexico, NM, U.S.A., 1972.

53. Flick, W. A. : "Resource Flows and Values". USDI, Bureau of land Management Tech. Note 276, U.S.A., 1975.

54. Fotso, Laurie : "Multiple Objective Linear Programming". Ph.D. Dissertation, Rensselaer Polytechnic Institute, 1981.

55. French, S. : "Interactive Multi-Objective Programming : Its Aims, Applications and Demands". J. of the Operational Research Society, Vol. 35, No. 9, The Operational Reserach Society Limited, Birmingham, U.K., 1984, pp. 827-834.

56. Gal, T., et al., : "Multiparametric Linear Programming". Management Science, Vol. 18, No. 7, The institute of Management Science, Providence, U,S.A., 1972, pp. 406-421.

57. Gary, R., et al., : "A Simplified Interactive Multiple Objective Linear Programming Procedure". Computer & Operations Research, Vol. 12, No. 6, Pergamoon Press Inc., England, 1985, pp. 589-601.

58. Gibert, K. C., et al., : "A Multiobjective Discrete Optimization Model for Land Allocation". Management Science, Vol. 31, No. 12, The Institute of Management Science, Providence, U.S.A., 1985, pp. 1509-1522.

59. Goicoechea, A., et al., : "Multiobjective Decision Analysis with Engineering and Business Applications". John Wiley, New York, U.S.A., 1982.

60. Gold, S. M. : "Recreation Planning for Energy Conservation ". Intern. J. Environmental Studies, Vol. 10, Gordon and Breach Science Publishers Ltd., G.B., 1977, pp. 173-180.

61. Gordon, S. I. : "Performing Land-capability Evaluation by Use of Numerical Taxonomy : Land Use and Environmental Decision Making Made Hard ?". Environment and Planning A, Vol. 10, Pion Limited, London, U.K., 1978, pp. 915-921.

62. Graefe, A. R., et al., : "Social Carrying Capacity : An Integreation and Synthesis of Twenty Years of Research". Leisure Science, Tayloy & Francis, Washington, D.C., U.S.A., 1984, pp. 395-431.

63. Greis, N. P., Wood, E. F. and E. S. Ralph : "Multicriteria Analysis of Water Allocation in A River Basin : The Tehebycheff Approach". Water Resources Research, Vol.19, No. 4, American Geophysical Union, Washington, D.C., U.S.A., 1983, pp. 865-875.

64. Haimes, Y. Y., Kaplan, M. A. and M. A. Husar : "A Multilevel Approach to Determining Optimal Taxation for the Abatement of Water Pollution". Water Resources Research (84), American Geophysical Union, Washington, D.C., U.S.A., 1972, pp. 851-860.

65. Hammon, G. A., et al., : "Capacity of Water-based Recreation System Part I : The State of Art - a literature review". Water Resource Research, Institute of the Univ. North Carolina, U.S.A., 1974, p. 49.

66. Hansen, Pierre(ed.) : "Essays and Surveys on Multiple Criteria Decision Making". Lecture Notes in Economics and Mathematical Systems, 209. Proceedings of the Fifth International Conference on Multiple Criteria Decision Making held at Mons, Springer-Verlag, Berlin-New York, August 9-13 1982.

67. Harris, C. C., et al., : "User Fees : 1. Pros and Cons". J. of Forestry, U.S.A., May 1987, pp. 25-29.

68. Hemming, T. : "Multiobjective Decision Making Under Certainty". EFI, Stockholm, 1978.

69. Hiller, F. S. and G. J. Lieberman : "Introduction to Operations Research". Holden-Day, Inc., San Francisco, U.S.A., 3rd. Ed., 1980.

70. Ho, Yu Feng : "Evaluation of Public Housing Space Standards in the Residential Community of New Town in Taiwan : A Systems Approach". Unpublished PhD thesis, LSE, London, U.K., 1983, p. 76.

71. Huang, Fu Szu : "Discussion on Environmental Planning Structure". (in Chinese), Chan's Pub. co., Ltd., Taipei, ROC, 1982, pp. 71-77.

72. Huber, G. : "Managerial Decision Making". U.S.A., 1980.

73. Hwang, C. L. et. al., : "Mathematical Programming with Multiple Objectives : A Tutorial". Computers and Operations Research, Vol. 1, No. 1, Pergamon Press Inc., U.K., 1977, pp. 39-54.

74. Ignizio, J. P. : "A Review of Goal Programming : A Tool for Multiobjective Analysis". J. of the Operational Research Society, Vol. 29, The Operational Research Society Limited, Birmingham, U.K., 1978, pp. 1109-1119.

75. Isermann, H. : "The Enumeration of the Set of All Efficient Solutions for a Linear Multiple Objective Program". Operation Research, Quart., Vol. 28, No. 3, The Operations Research of America, Baltimore, U.S.A., 1977, pp. 711-725.

76. Kannanen, Ilkka et al., : "Multiple Objective Analysis of Input-output Models for Evergeney Management." Operations Research, Vol. 38, No. 9, The Opeations Research of America, Batimore, U.S.A., March-April 1990, p. 193.

77. Kaplan, R. : "The Analysis of Perception via Preference : A Strategy for Studying How the Environment Is Experienced". Landscape Planning, Vol. 12, No. 2, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, August 1985, pp. 161-176.

78. Karwan, M. H., Zionts, S. and B. Villarreal : "An Improved Interactive Multicriteria Interger Programming Algorithm". Working Paper No. 530, School of Management, Univ. of N.Y. at Buffalo, U.S.A., 1982.

79. Ko, Che Tung : "Discussion on Evnironmental Conservation Laws". Published in Symposium for Natural Environment Planning and Conservation Problems. Taipei, ROC, June 1983, pp. 21-23.

80. Korlduth, J. S. H. and R. E. Steuer : "Multiple Objective Linear Fractional Programming". Management Science, Vol. 27, No. 9, The Institute of Management Science, Providence, U.S.A., 1981, pp. 1024-1039.

81. Korhonen, P. and Laakso, J. : "A Visual Interactive Method for Solving the Multiple Criteria Problem". European Journal of Operational Research, Elsevier Science Publisher, B.V., Amsterdam, The Netherlands, 1986, pp. 227-287.

82. Kun, J. K. : "Administration". (in Chinese), Wu Nan Pub. Co. Ltd., Taipei, ROC, 1982.

83. Kwok, C. C. Y., et al., : "Composite Foreign Exchange Forecasting to Managers of Multinational Corporations". Management International Review, Vol. 28, No. 19, Gabler Verlay, Wiesbaden, Germany,

October, 1988, p. 15.

84. Lanton, S.(ed) : "Citizen Participation in America". 1978.

85. LaPage, Wilbur F. : "Some Aspect of Forest Recreation". J. of Forestry, U.S.A., 1983, pp. 32-36.

86. Lawrence, K. D., Lawrence, S. M. and G. R. Reeves : "Aggregate Industrial Expansion : A Multiple-Objective Linear Programming Formulation". Engineering Economist, Vol. 25, No. 3, American Society for Engineering Education and American Institute of Engineers, Inc., Norcross, U.S.A., Spring 1980, pp. 197-207.

87. Lee, S. M. : "Goal Programming for Decision Analysis of Multiple Objective". Sloan Management Rev., 14, The Sloan Management Review Association, U.S.A., 1973, pp. 11-24.

88. Legasto, A. A. : "A Multiple-objective Policy Model : Results of An Application to A Developing Country". Management Science, Vol. 24, No. 5, The Institute of Management Science, Providence, U.S.A., January 1978, pp. 498-509.

89. Li, M. T. : "Brief Introduction - Public Participation in National Park Planning Process in the U.S. and Canada". Taiwan Forestry, Vol. 12, No. 5, Taipei, ROC, 1986, pp. 12-13.

90. Lime, D. W. and G. H. Stankey : "Carrying Capacity : Maintaining Outdoor Recreation Quality". Recreation Sym. Proc., College of Forestry, Syracuse, N. Y., U.S.A., October 12-14, 1971.

91. Lin, Y. C. : "A Survey and Report of the Recreation Carrying Capacity of Yu-Shan National Park". (in Chinese) Tung Hai University, Taichung, ROC, 1987, pp. 26-131.

92. Lin, W. T. : "Multiple Objective Budgeting Models : A Simulation". Accounting Review, Vol. 53, No. 1, The American Accounting Association, George Banta Company,

Inc., Wisconsin, U.S.A., January 1978, pp. 61-76.

93. Low, S. M. : "Social Science Methods in Landscape Architecture Design". Landscape Planning, Vol. 8, Elsevier Science Publishers, B.V., Amsterdams, The Netherlands, 1981, pp. 137-148.

94. Lucas, R. C. (ed.) : "Proceedings -- National Wilderness Research Conference : Current Research". USDA, Forest Service, Gen. Tech. Rep., INT-212, U.S.A., 1986.

95. Matteiss, T. H. et al., : "A Tree Breeding Strategy Based on Multiple Objective Linear Programming". Interfaces, Univ. of Alabama, Vol. 14, No. 5, U.S.A., Sept./Oct., 1984, pp. 1376-1384.

96. Mehrez, A., et al., : "A Note on Multiplicative Utility in Interactive Project Selection". J. of the Operational Research Society, Vol. 34, No. 11, The Operational Research Society Limited, Birmingham, U.K., 1983, pp. 1123-1124.

97. McDonald, G. T., et al., : "The Regional Economic Impact of Tourism and Recreation in National Parks". Environment and Planning B : Planning and Design, Vol. 13, Pion Limited, London, U.K., 1986, pp. 349-366.

98. McHarg, I. : "Human Ecological Planning at Pennsylvania". Landscape Planning, Vol. 8, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1981, pp. 109-120.

99. McHarg, I. : "Design with Nature". American Museum of Natural History, N.Y., U.S.A., 1971.

100. Miller, W. L., et al., : "Development and Display of Multiple-objective Project Impact". Water Resources Research, 9(1), American Geophysical Union, Washington, D.S., U.S.A, 1973, pp. 11-20.

101. Taiwan, Ministry of Interior : "Public Housing Construction Long-range Plan Research". Ministry of Interior, Taiwan, 1978, pp. 81-83.

102. Monarchi, D. E., et al.,: "Interactive Multiobjective Programming in Water Resources : A Case Study". Water Resources Research, Vol. 9, No. 4, American Geophysical Union, Washington D.C., U.S.A., 1973, pp. 837-850.

103. Moncrief, L. W. : "The Recreation Experience : Its Implications for Planning and Design". International Symposium on Landscape and Recreational Planning, Taipei, ROC, 1985.

104. Nerikar, V. N. : "Gauging Florida's Carrying Capacities by : root count, water seep, humus depth, leaf litter, soil density, plant diversity". Landscape Architecture, The American Society of Landscape Architects, Washington, D.C., U.S.A., March 1976, pp. 133-137.

105. Parker, B. J. and G. A. Alutaibi : "Decision Support System : The Reality that Seems Hard to Accept ?". OMEGA, The International of Management Science, Vol. 14, No. 2, Pergamon Press, Inc., U.K., 1986, pp. 135-143.

106. Pearl, L. : "A Land Use Design Model". Urban Studies, Carfax Publishing Company, Oxfordshire, U.K., November 1974, pp. 315-321.

107. Penz, A. J. : "Outdoor Recreation Areas : Capacity and the Formulation of Use Policy". Management Science, Vol. 22, No. 2, The Institute of Management Science, Providence, U.S.A., 1975.

108. Perry, J. Brown : "Planning for the Use of Recreation Resources". International Symposium on Landscape and Recreational Planning, Taipei, ROC, 1985.

109. Prest, A. R. and B. R. Turvey : "Cost Benefit Analysis". J. of Economic Survey, Basil Blackwell, Ltd., Offord, England , 1965. p. 689.

110. Reeves, G. R., Lawrence, K. D. Lawrence, S. M. and J. B. Guerard Jr. : "Combining Earnings Forecast Using Multiple Objective Linear Programming". Computers and Operations Research, Pergamon Press, Inc., U.K., 1988, 15, 6 : 551-559, ISSN: 0305-0548.

111. Robinson, A. H. : "Planning Consideration for Preservation and Use of the National Seashores". Coastal Zone Management Journal, Newsletter of Coastal Resource Development, Conservation and Enhan cement, 1979, 5(1/2): 5-34.

112. Rust, R. E. : "Sausage and Meats Manufacturing". AMI Center for Continuing Education, American Meat Institute; Washington, D. C., U.S.A., 1976.

113. Sai, A. S. R., Ramakrishnan, T. S. and J.K.S. Roa : "Slum Modernization through Mathematical Programming". Building and Environment, Vol. 13, Pergamon Press, Inc., N.Y., 1978, pp. 7-10.

114. Seagle, J. P., et al., : "The Feature Chart : A Tool for Communicating the Analysis for a Decision Support System". Information and Management, Vol. 10, No. 1, International Federation for Information Systems Applications. International, Federation for Information Processing, Applied Information Processing Group, North-Holland, 1986.

115. Seiford, L. and P. L. Yu : "Potential Solutions of Linear Systems : The Multi-Criterion Multiple Constraint Levels Program". J. Math. Anal. Appl., Vol. 69, No. 2, U.S.A., 1979, pp. 283-303.

116. SEWRPC : "The Total Of the Space Requirement for Each Physical Unit Comparing the Module". Southeastern Wisconsin Ragional Planning Commission, U.S.A., 1973, p. 3.

117. Shamir, U., et al., : "Optimal Annual Operation of A Coastal Aquifer". Water Resources Research, Vol. 20, No. 4, American Geophysical Union, Washington, D.C., U.S.A., 1984, pp. 435-444.

118. Shapiro, P. : "Environmental Quality and Economic Development". Environment and Planning A, Vol. 11, Pion Limited, London, U.K., 1979, pp. 1147-1156.

119. Shely, B., et al., : "A Conceptual Framework for Carrying Capacity Determination". Leisure Science, Tayloy & Francis, Washington, D.C., U.S.A., 1984, 6: 433-451.

120. Shelby, B. : "Crowding Models for Backcountry Recreation Land Economics". 1980, 56:43-55.

121. Shelby, B. : "Social Psychological Effects of Crowding in Wilderness : The Case of River Trips in the Grand Canyon". 1976.

122. Sinuany-Stern, Z. : "A Network Optimization Model for Budget Allocation in A Multi-Campus University". J. of the Operational Research Society, Vol. 35, No. 8, The Operational Research Society Limited., Birmingham, U.K., 1984, pp. 749-457.

123. Smart, G. : "Nature Conservation and Planning". Town Planning Review, Vol. 49, No. 4, Liverpool Univ. Press, England, October 1978, pp. 540-550.

124. Smith, K. V. F. : "Nature Conservation in Wandsworth". , Leisure Manager, J. of Institute of Leisure and Amenity Management, John S, Turner & Associates Ltd., Cambridge, England, January 1984, pp. 9-11.

125. Simmons, I. G. : "Prehistory and Planning on the Moorlands of England and Wales". Landscape and Urban Planning, Vol. 17, Elsevier Science Publishers, B.V., Amsterdam, The Netherlands, 1989, pp. 251-260.

126. Soloveichik, D. : "A New Approach to Decision Making in Multiple-Objective Linear Programming (MOLP) Problems". Report from the Moscow refusnik seminar, New York Acad. Science, New York, U.S.A., 1987, pp. 245-252.

127. Stankey, G. H. : "Carrying Capacity in Recreational Planning : An Alternative Approach." International Symposium on Landscape and Recreational Planning, Taipei, ROC, 1985.

128. Stankey, G. H. : "Visitor Perception of Wilderness Recreation and Carrying Capacity". US Forest Service, Research Paper INT-142, U.S.A., 1973.

129. Stankey, G. H. : "Wilderness Carrying Capacity". In Hendee, et al., Wilderness Management. US Forest Service Miscellaneous Publication., No. 1365.

Washington, D. C. U.S.A., 1978.

130. Stankey, G. H., et al., : "The Limits of Acceptable Change : A New Framework for Managing the BOB Marshall Wilderness Complex". Western Wildlands, Vol. 11, No. 3, Univ. of Montona, Missoula, MT, 1984, pp. 33-37.

131. Stankey, G. H., et al., : "The Limits of Acceptable Change for Wilderness Planning". USDA Forest Service Gen. Tech. Report, INT-176 USDA., Intermountain For. and Range Exp. Sta. Ogden, Ut., U.S.A., 1974.

132. Steuer, R. E. : "ADBASE : An Adjacent Efficient Basis Algorithm for Vector-Maximum and Interval Weighted - Sums Linear Programming Problems". College of Business and Economics, Univ. of Kentucky, Lexington, U.S.A., 1974.

134. Steuer, R. E. : "Multiple Objective Linear Programming with Interval Criterion Weights". Management Science, Vol. 23, No. 3, The Institute of Management Science, Providence, U.S.A., 1976, pp. 455-462.

135. Steuer, R. E. : "Operating Manual for the ADBASE Multiple Objective Linear Programming Computer Package". (Relase : 8/80), College of Business Administration, University of Georgia, U.S.A., 1982.

136. Steuer, R. E. and F. W. Harris, : "Intra-Set Point Generation and Filtering in Decision and Criterion Space". Computers and Operations Research, Vol. 7, No. 1-2, Pergamon Press, Inc., U.K., 1980, pp. 41-53.

137. Steuer, R. E. : "Sausage Blending Using Multiple Objective Linear Programming". Management Science, Vol. 30, No. 11, The Institute of Management Science, Providence, U.S.A., November 1984, pp. 1376-1384.

138. Steuer, R. E. and R. L. Oliver : "An Application of Multiple Objective Linear Programming to Media Selection". OMEGA, The Int. of Management Science, Vol. 4, No. 4, Pergamon Press Inc., U.K., 1976, pp. 455-462.

139. Su, H. C. : "A Criticism on the Methodology of the

Impact of Outdoor Recreation on Natural Plant Community and Its Study Results". (in Chinese), A Report of National Taiwan Univ., Taipei, ROC, 1987.

140. Sung, B. M. : "A Study of Recreation Carrying Capacity Theory". (in Chinese), Unpub. MSc. thesis of National Taiwan Univ., Taipei, ROC, 1984, p. 32.

141. Sutcliffe, C., Board, J. and P. Cheshire : "Goal Programming and Allocating Children to Secretary Schools in Reading". J. of the Operational Research Society, Vol. 35, No. 8, The Operational Research Society Limited, Birmingham, U.K., 1984, pp. 719-730.

142. Szidarovszky, F., et al., : "Dynamic Multiobjective Control of Mining, Water Supply and Environmental Effects". Working Paper No. 80-1, Univ. of Arizona, U.S.A., 1980.

143. Taichung City Government : "Master Plan First Review Instruction of Changing Taichung City Urban Plan (Ta-Keng Scenic Area)".(in Chinese), A Report of Taichung City Government, Taichung, Taiwan, ROC, 1988, pp. 9-12.

144. Taichung Shen Government : "The Comprehensive Plan of Houli Horse Riding Field and Its Surrounding Area". (in Chinese), A Report of Taichung Shen Government, Taichung, Taiwan, ROC, 1988, pp. 55-76.

145. Taiwan, Bureau of Environmental Protection : "Environment Protection Acts and Codes". (in Chinese), A report of Bureau of Environmental Protection, Taichung, Taiwan, ROC, 1984, pp. 151-154.

146. Taiwan, Construction and Planning Administration, Ministry of Interior : "National Park Acts and Codes". (in Chinese), A Report of Ministry of Interior, Taipei, ROC, 1983, pp. 2-4.

147. Taiwan, Construction and Planning Administration, Ministry of Interior : "The Report on Scope and Boundary Determination of the Yu-Shan National. Park". (in Chinese), A Report of Ministry of Interior, Taipei, ROC, 1982, p. 1.

148. Taiwan, Construction and Planning Administration, Ministry of Interior : "Urban Plan Acts and Codes-- Urban Plan Act". (in Chinese), A Report of Ministry of Interior, Taipei, ROC, 1983, pp. 1-22.

149. Taiwan, Construction and Planning Administration, Ministry of Interior : "Urban Plan Act -- District Plan Act". (in Chinese) , A Report of Ministry of Interior, Taipei, ROC, 1983, pp. 287-294.

150. Taiwan, Construction and Planning Administration, Ministry of Interior : "Urban Planning Acts Related Articles". (in Chinese), A Report of Ministry of Interior, Taipei, ROC, 1983, pp. 363-372.

151. Taiwan, Ministry of Interior : "Cultural Property Conservation Acts and Execution Rules". (in Chinese), A Report of Ministry of Interior, Taipei, ROC, 1984.

152. Taiwan, Construction and Planning Administration, Ministry of Interior : "The Report on Scope and Boundary Determination of Ta-Rou-Ko National Park". (in Chinese), A Report of Ministry of Interior, Taipei, ROC, 1986, p. 2.

153. Taiwan Provincial Government: "The Central Regional Plan of Taiwan". (in Chinese), A Report of Taiwan Province Government, ROC, 1971, pp. 129-267.

154. Taiwan, Tourism Bureau, Ministry of Communications : "Monthly Report on Tourism". (in Chinese), Taipei, ROC, 1989.

155. Taiwan, Tourism Bureau, Ministry of Communications : "Special Scenic Area Administration Regulations". (in Chinese), Taipei, ROC, 1985, pp. 2-3.

156. Taiwan, Tourism Bureau, Ministry of Communications : "Tourism Industry Related Acts and Codes -- Taiwan Province Forest Recreation District Administration Codes". (in Chinese), Taipei, ROC, 1986, pp. 419-422.

157. Tivy, Joy : "The Concept and Determination of Carrying Capacity of Recreational Land in the U.S.A.". Countryside Commission for Scotland, CCS Occasional Paper No. 3, U.K., 1972.

158. The Department of Urban Planning. Feng Chia University : "A Study on the Recreation System of Taiwan". (in Chinese), A Report to the Tourism Bureau, Taiwan, ROC, 1988, p. 47.

159. Torkildsen, G. : "Leisure and Recreation Management". E & F.N. Spon Ltd., London, U.K., 1983, p. 211.

160. Taiwan, Tourism Bureau, Ministry of Communications "Annual Report on Tourism Statistics". (in Chinese), Taipei, ROC, 1987, pp. 48-49.

161. Town and Country Consultant Company Limited : "Primary Plan of Ta-Kuan Mountain Scenic Area and Ta-Kuan Mountain Nature Reserve". (in Chinese), A Report to Tourism Bureau of Taiwan, ROC, 1988, pp. 66-67.

162. Travis, A. S. : "Planning As Applied Ecology". Town Planning Review, Vol. 48, No. 1, Liverpool Univ. Press, England, January 1977, pp. 5-16.

163. Turaff, M., et al., : "The Delphi Method : Techniques and Applications". Addison-Wesley Publishing Company, Massachusetts, U.S.A., 1980, pp. 5-10.

164. Urban Planning Association of ROC : "Taipei Shen Tourism and Recreation Development Comprehensive Plan". (in Chinese), A Report to Taipei Shen Government, ROC, June 1986.

165. Urban Research Development Corporation : "Optimum Recreation Carrying Capacity". Bureau of Outdoor Recreation, USDI, U.S.A., 1977.

166. U.S. Dept. of Agriculture, Forest Service : "Goal Programming Manual". Forest Service Eastern Region Milwaukee, Wisc., 1974, U.S.A., p. 45.

167. Vernuri, V. : "Multiple Objective Optimization in Water Resources Systems". Water Resources Research, Vol. 10, No. 10, American Geophysical Union, Washington, D.C., U.S.A., 1974, pp. 44-48.

168. Villarreal, B., et al., : "An Interactive Dynamic

Programming Approach to Multicriteria Discrete Programming". J. Math. Anal. Appl., 81. U.S.A., 1981, pp. 524-544.

169. Vink, A.P.A. : "Landscape Ecology and Land Use". Longman Group Ltd., London and New York, 1983, p. 4.

170. Viswanathan, B., Aggarwal, V. V. and K. P. K. Nair : "Multiple Criteria Markov Decision Processes". Management Science, The Institute of Management Science, Providence, U.S.A., 1977, pp. 263-272.

171. Wager, T. A. : "The Carrying Capacity of Wildlands for Recreation". For. Sci. Monogr. 7, 1964, pp. 23-39.

172. Wang, H. : "Idea About Recreation Planning and Natural Aesthetic Administration". Chinese Garden Making Quarterly, (in chinese) Vol. 1, No. 2, Taipei, ROC, 1985, pp. 30-31.

173. Wang, H. F., et al., : "Group Decision Support with a MOLP Application". IEEE Transection on Systems, Man and Cybernetics, Vol.19, No.1, 1989. U.S.A., pp. 143-153.

174. Wang, H. L. : "A Study on Landscape Planning and Design for the First Nuclear Power Plant Site". (in Chinese), A Report to the Taiwan Power Company, Taipei, ROC, 1986.

175. Wang, H. L. : "A Study on Landscape Planning and Design for the Shen-Aoh Power Plant Site". (in Chinese), A Report to the Taiwan Power Company, Teipei, ROC, 1987.

176. Wang, H. L. : "A Study on Landscape Planning for the Third Nuclear Power Plant Site and Its Surrounding Areas". (in Chinese), A Report to the Taiwan Power Company, Taipei, ROC, 1985, pp. 47-56.

177. Wang, H. L. : "Landscape Planning and Design For Housing Estate". (in Chinese) Taiwan Architectural Information Semimonthly, Taipei, ROC, 1983, pp. 53-60.

178. Wang, H. L. : "Landscape Planning and Design for New

Towns". (in Chinese), <u>Chinese Architect</u>, Taipei, ROC, 1982, pp. 36-43.

179. Wang, H. L., et al., : "Electric Power Station and Visual Amenities Planning". (in Chinese), <u>J. of Feng Chia Univ</u>. Vol. 20, Publisohed by Feng Chia Univ., Taichung, Taiwan, ROC, 1987, pp. 443-462.

180. Wang. H. L. : "A Study of the Ta-Keng Hillside Housing Estate Development Models in Taichung". (in Chinese), A Report to Taichung City Government, Taichung, Taiwan, ROC, 1988.

181. Wang, H. L. and Y. F. Ho : "A Study on Ta-Keng Tourism Farm Village Planning". (in Chinese), A Report to Taichung City Government, Taichung, Taiwan, ROC, 1989, pp. 79-81.

182. Wilson, A. G. : "The Aim of Urban Land Use Plan Design is the Optimisation of the Use of Land Space". 1974, p. 19.

183. Wu, L. Y. : "Study on Taipei Park Design and Planning System". (in Chinese), Published by Parks and Street Lights Administration, Taipei City Government, Taipei, ROC, 1983, p. 4.

184. Wu, Y. L. : "A Study on the Measurement of Recreation Carrying Capacity for the Camping Sites of Yu-Shan National Park ". (in Chinese), Urpub. MSc thesis, Chung Hsing Univ., Taipei, ROC, 1987, p. 111.

185. Young, K. S., et al., : "Social and Behavioural Study Methodology". (in Chinese) (Volumes I,II), Tung Hwa Book Co., Taipei, ROC, 1988, pp. 406-438.

186. Zelney, M. : "Multiple Criteria Decision Making". McGraw-Hill Book Company, N.Y., U.S.A., 1982.

187. Zeleny, M. : "Multicriteria Simplex Method : A Fortran Routine". Lecture Notes in Economics and Mathematical Systems, No. 123, Springer-Verlag, Berlin and New York, 1976, pp. 323-345.

188. Zionts, S., et al., : "An Interactive Multiple

Objective Linear Programming Method for a Class of Underlying Nonlinear Utility Functions". Management Science, Vol. 29, No. 5, The Institute of Management Science, Providence, U.S.A., May 1983, pp. 519-529.