Université de Montréal

LANDSCAPE ECOLOGICAL ANALYSIS OF THE NORTHWESTERN ARID COAST OF EGYPT: CASE STUDY OF BURG EL-ARAB/EL-HAMMAM AREA

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Thèse présentée à la Faculté des études supérieures
en vue de l'obtention du grade de
Philosophiæ Doctor (Ph.D.)
en aménagement

Juillet 1999

Université de Montréal

Faculté des études supérieures

Cette thèse intitulée :

Landscape Ecological Analysis of the Northwestern
Arid Coast of Egypt :
Case Study of Burg El-Arab/El-Hammam Area

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Thèse acceptée le : 21 février 2000

Summary

The demand for alternative productive land in Egypt dictated land-use plans that traced short-term solutions. These plans aimed at maximizing economic gain, and lacked understanding of landscape concepts. This resulted in devastating effects on the natural resources and the social fabric, particularly in the western Mediterranean coastal region. The following questions may be raised: (a) What would be the approach for elucidating the interactions between the arid landscape attributes? (b) Which attributes are to be taken into consideration in landscape analysis? (c) By testing the proposed approach in a pilot study area, would it be valid for application in the Mediterranean? (d) How could the adopted approach be modified for better application? Accordingly, the present study adopted the following objectives: (a) to assess the usefulness of landscape ecological concepts in understanding landscape changes. (b) To adopt an approach for evaluating landscape changes in arid coasts and to test its application in a selected pilot area. (c) To elaborate a framework of a landscape-planning model that could be applied to other desert areas of Egypt.

The selected study area is located 20-km west of Alexandria, and expands 20 km westward. It is described in terms of its ecological indices (patch number, size and shape), and visual indices (activity, and diversity). The socioeconomic attributes are the "demographic population distribution by age category", and the "economic activities of the population". The spatial data, that consisted of a topographic map, aerial photographs of 1955 and 1977, and SPOT XS and panchromatic satellite images of 1987 and 1992, were classified. The resulting classes were coastal dunes, crop fields, orchard fields, ploughed fields, pastureland and natural vegetation, urban areas, flooded salt marshes, salt marsh vegetation, and quarries. The coastal dunes lost 12% of their area, and were fragmented into isodiametric, man-made patches. The area of agricultural land also was decreased and fragmented. The urban class was increased in area and in number of patches. The visual characteristics exhibited a notable transition from higher to lower scores. Fragmented natural and agricultural patches increased the "diversity" index and the "activity" values, which resulted in higher scores of visual characteristics. Also, there was a notable increase in the population, particularly the number of inhabitants of 10 years and younger. There was a loss in the total working population, although the number of inhabitants working in non-agricultural activities increased.

In conclusion, ambiguity in explaining the changes in ecological attributes calls for evaluating their relationships with other attributes in more depth. It also indicates the need of considering socio-economic attributes in more depth. Other factors beside those dealt with, need to be taken into consideration, such as national and international political systems, the adaptation of local inhabitants to the arid environment, and the decision making process.

Finally, a framework of a landscape-planning model is proposed, which provides several possibilities that are often ignored. Local participation and capacity building are emphasized. It combines making use of the merits of comprehensive analysis in generating new information input, and the flexibility of starting the planning process with whatever such information is available. A plan of data collection is proposed taking into consideration the availability of data, the relative importance of attributes in the analysis process, and the human resources capable of conducting such analysis.

The present study is an endeavor that may be considered unique to the western Mediterranean region and indeed to other desert areas of Egypt in different aspects. First, it extends the possibilities of data integration, by adopting the holistic approaches of landscape ecology in analyzing arid landscape evolution. Second, it uses innovative methods in analyzing the visual resources of arid landscapes using remotely sensed data and satellite image processing, and sets an example for future analyses of such an incommensurable resource. Also, it integrates different and varied data types in a Geographic Information System and uses statistical and multivariate analyses to explore the interrelationships between different types of landscape attributes. Finally, it sets a framework of a planning model in the form of activities to ensure its applicability and to provide the most significant attributes and information input before and during the plan formulation.

Résumé

Vu l'importante concentration de la population le long du Nil et le manque de zonage, de planification et d'aménagement municipal, l'environnement est soumie à un changement alarmant, particulièrement sur la côte nord-ouest de l'Égypte.

Le problème de l'environnement relatif au développement anarchique des surfaces urbaines, périurbaines et rurales, tel qu'observé sur les plans théorique et pratique, reflète une caractéristique importante de la dégradation de l'environnement, de ses causes et de ses effets sur le milieu. Au delà de l'identification ponctuelle de phénomènes ou de problèmes particuliers, il est nécessaire d'élaborer un cadre conceptuel qui pourra servir à la recherche de données sur l'environnement du nord-ouest égyptien, à leur analyse, à leur interprétation et à des interventions sur l'aménagement du territoire. Nous avons procédé pour cela à une réflexion basée sur l'étude de plusieurs documents, textes, cartes, photographies aériennes, images satellitaires et données statistiques.

Cette réflexion a permis de définir les grandes lignes de la problématique environnementale qui constituera le fondement conceptuel de cette thèse sur l'écologie du paysage de la côte nord-ouest de l'Égypte, le cas de la région de Burg El-Arab et d'El-Hammam. En partant du constat de la dégradation des paysages, on peut remonter aux sources de cette dégradation du milieu. Les activités humaines et économiques de même que les causes naturelles sont identifiées comme les sources de cette détérioration du milieu paysager de la côte nord-ouest égyptienne. Les effets sur l'environnement naturel et humain y sont précisés. Finalement, les solutions et actions nécessaires pour corriger cette situation sont évoquées. Dans cette perspective, les objectifs sont abordés de la manière suivante:

- Évaluer l'utilité des concepts de l'écologie du paysage dans la compréhension de l'évolution du paysage aride de la côte nord-ouest de l'Égypte;

- Établir une approche holistique d'analyse et d'évaluation de l'évolution du paysage de la côte nord-ouest de l'Égypte incluant des caractéristiques écologiques, visuelles et socio-économiques, en testant son application sur un territoire pilote; et,

- Élaborer un modèle d'aménagement du territoire sur les régions choisies et celles d'un milieu comparable.

Les différents objectifs fournissent un cadre de référence qui permet d'aborder de manière systématique le concept de l'écologie du paysage. Ainsi pour chaque phénomène ou problème environnemental, on établira, outre sa localisation spatiale, ses causes et ses sources, de même que ses effets sur les différentes composantes de l'environnement. On peut ainsi établir pour chaque phénomène ou problème, le contexte naturel, économique ou social dans lequel il s'inscrit, et les répercussions qu'il engendre sur le milieu naturel ou humain. Le contenu des données provenant des images satellitaires demeure essentiel et aura l'avantage de servir au traitement, à l'analyse et à l'interprétation des différents milieux du territoire à l'étude.

Pour cela une approche systématique s'avère indispensable, afin de bien comprendre les interrelations qui existent entre le domaine naturel et le domaine humain (écologique, visuel et socio-économique). À partir de cette approche nous avons élaboré trois indices: la forme, la dimension et le nombre de polygones* basé sur la déviation de la forme isodiamétrique. Les évaluations des formes visuelles du paysage sont basées sur l'utilisation des informations acquises à partir des images satellitaires. Deux caractéristiques visuelles sont utilisées: la première est "l'activité", qui établit la proportion de la composante "naturelle" et se base sur les caractéristiques physiques du paysage. La seconde caractéristique est la "diversité" qui mesure la variété et la configuration proportionnelle de l'utilisation du sol par unité de surface, en utilisant les principes de l'esthétique. Les caractéristiques socio-économiques

* Notion utilisée par les concepts de l'écologie du paysage qui représente les surfaces occupées par des divers utilisations du sol.

sélectionnées portent sur la population par groupe d'âges et les activités économiques de cette dernière.

Nous avons effectué un inventaire des cartes topographiques, des photographies aériennes des années 1955 et 1977, et des images satellitaires pour les années 1987 et 1992. À partir de ces données cartographiques et photographiques nous avons cherché à identifier et analyser l'utilisations du sol pour les années 1955 et 1977. Neuf classes sont définies: (1) les dunes côtières, (2) les espaces agricoles, (3) les vergers, (4) les terrains préparés pour l'agriculture, (5) les régions de pâturage et de végétation naturelle, (6) les espaces urbains, (7) les marais salants, (8) les végétations des marais salants, et (9) les carrières.

Les deux secteurs physiographiques les plus importants sont: le secteur côtier des dunes et la dépression non-saline, puisqu'ils ont connu une dégradation importante. Dans le premier secteur, la surface des dunes côtières a diminué d'environ 12%. Ces dunes ont été également soumises à un processus de fragmentation qui a eu comme conséquence l'augmentation du nombre de polygones, ces derniers ont été transformés de manière anthropique de forme isodiamétrique. Également, la région agricole a été diminuée et les champs en culture on été réduits. Les espaces bâtis, les carrières, et les chantiers de construction ont augmenté en surface et en nombre de polygones dans ce secteur. Les caractéristiques visuelles ont montré une diminution des points. Dans le deuxième secteur, l'augmentation de la surface et la fragmentation des polygones des marais salants étaient remarquables. Les changements de la région agricole étaient semblables à ceux qui ont eu lieu dans le premier secteur. L'augmentation des espaces bâtis a été principalement concentrée dans la région de Burg El-Arab et El-Hammam, et l'augmentation du nombre de polygones a indiqué la propagation et la dispersion des espaces bâtis plus loin vers l'intérieur. La classe d'activité de la combinaison de "mi-naturelle/naturelle" a diminuée vigoureusement, alors que les classes d'activités "artificielle", "artificielle/naturelle" et des secteurs mixtes augmentaient graduellement. Ceci est dû à l'augmentation de la classe "naturelle" de la végétation des marais salants et à la diversification des pratiques agricoles. Les polygones fragmentés de types "naturels" et "agricoles" ont augmenté la diversité et les valeurs d'"activité". Au point de vue démographique, la population totale a augmenté de 24 912 entre 1960 et 1986 pour atteindre 36 618 habitants avec un taux de croissance d'environ de 6%. Le groupe d'âge 10 ans et moins a connu une augmentation de sa population.

Les résultats indiquent des enjeux importants pour l'analyse de paysage dans les régions arides côtières. D'abord, il y a une certaine ambiguïté en expliquant les changements des caractéristiques écologiques, qui tracent un rappel pour l'évaluation des rapports entre ces derniers et les autres caractéristiques. En second lieu, en dépit de la difficulté produite en rassemblant des informations sur les caractéristiques socio-économiques, la présente recherche indique l'importance de considérer ces caractéristiques de manière plus appprofondie, et d'assimiler leurs rapports avec les autres caractéristiques de paysage. Finalement, l'application des analyses statistiques et multivariées démontre la possibilité d'intégrer les caractéristiques qui sont apparemment de nature différente (par exemple écologique, visuelle et socio-économique).

L'interprétation de l'information permet d'adopter certaines méthodes pour l'évolution du paysage dans la région d'étude. Ce paysage résulte de l'influence d'autres facteurs. Par exemple, l'instabilité des systèmes politiques, l'adaptation des habitants aux conditions de vie difficile de l'environnement aride et l'ambiguïté du processus de prise de décision. Ces facteurs sont tous considérés comme des effets pouvant modifier le paysage de la région. Considérant ces effets sur la dynamique du paysage aride côtier, nous proposons un modèle de planification du paysage pour l'application dans le désert côtier à l'étude. Ce nouveau modèle tient compte des facteurs principaux affectant la structure et la dynamique de paysage. Il est basé sur des concepts de l'écologie de paysage, en respectant les caractéristiques spécifiques du paysage aride côtier. Il fournit plusieurs autres possibilités qui sont souvent ignorées dans les modèles actuels. Par ce modèle, la participation locale du développement par des acteurs, particulièrement les bédouins, est assurée. La connaissance des autochtones est indispensable. Dans son application, le modèle pourrait également assurer le rôle de la formation des cadres professionnels et institutionnels. Il adopte une approche hybride, et analyse d'une manière globale le paysage dans la production des nouvelles sources d'information. Il acquiert, enfin, la flexibilité d'élaborer le processus de planification en utilisant l'information existante.

La présente thèse offre les possibilités d'intégration des données en adoptant l'approche holistique de l'écologie de paysage dans l'analyse de l'évolution des paysages arides. En second lieu, elle a employé des méthodes innovatrices en analysant les ressources visuelles du paysage aride à l'étude employant des données acquises par les moyens de télédétection et de traitement des images satellitaires. Cet essai représente un exemple qui peut être appliqué dans une analyse plus complète des ressources visuelles des régions arides. En outre, elle permet l'intégration des différentes données dans un système d'information géographique (SIG), et l'analyse statistique utilise des corrélations entre les caractéristiques du paysage. Elle offre, finalement, un cadre conceptuel de “modèle de planification” sous la forme d'activités afin d'assurer son applicabilité et la sélection des attributs et des données les plus significatives avant et pendant la formulation du plan d'aménagement du territoire.

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DEDICATION

To Allah, the most merciful,

■ Do they not look at the sky above them? How We have made it and adorned it, and there are no flaws in it? ■ And the earth-We have spread it out, and set thereon mountains standing firm, and produced therein every kind of beautiful growth (in pairs)- ■ For an insight and reminder to every servant Turning to Allah ■ And We send down from the sky rain charged with blessing, and We produce therewith gardens and grain for harvests ■ and tall (and stately) palm-trees, with shoots of fruit-stalks, piled one over another ■ As sustenance for (Allah's) servants;-and We give (new) life therewith to land that is dead: thus will be the resurrection ■

{Holy Quran, Kaaf 6-11}

ACKNOWLEDGEMENT

I would like to extend special thanks to my professors, Michel Guenet and Gerald Domon for their efforts in the amelioration of this thesis. Their advises and comments were valuable. Their support and patience is greatly appreciated.

Also I would like to thank the Department of Environmental Studies, Faculty of Science, University of Alexandria in Egypt for providing the topographic maps, the aerial photographs and the satellite images, without which this work wouldn't be possible.

Finally, special thanks go to my family whose support and encouragement have been of great help for me for years.

CHAPTER I: INTRODUCTION

There has been growing awareness since the sixties of the need to bring environmental values to the landscape planning and the management of its natural resources. Authors such as McHarg (1969), Lewis (1964), and Hills *et al.* (1970) have brought into focus an evolving philosophy that the understanding of the ecological processes provide the indispensable basis for planning and design. However, it is primordial, prior to planning and management, to understand the functioning and the interactions between landscape elements. Forman and Godron (1986) write:

> *"To see the future clearly, we must absorb and build on history as it is mirrored in the present. Perhaps the most informative mirrors of the present are our degraded landscapes... The surface area of degraded landscapes extends year by year almost inexorably, especially in some tropical countries and arid zones ... In fact, the single greatest difficulty in managing most landscapes is our lack of knowledge of the forces that underlie landscape change."*

Therefore, a basic scientific ingredient in any environmental management policy should be an understanding, at the outset, of the full complexity of the landscape structure and function. If for whatever pragmatic reasons some parts or aspects are ignored, there should be full appreciation of the consequences on environmental conditions (Ayyad, 1982).

Up to the present, the human factor in landscape dynamics has often been dealt with in a complementary manner, although it is usually the overriding "factor", particularly in the "human-altered" landscapes. Besides, most studies on the human impacts causing landscape changes tend to deal more with the changes in the biophysical factors, and to consider the effects of only specific human activities on the natural components of the landscape.

Thus a comprehensive approach to dealing with landscape evolution is required especially in arid and semi-arid regions of developing countries where chaos in policy making and actions is common. Under the marginal conditions of ecosystems in these regions, the dynamic equilibrium is fragile and minor changes in the physical environment entail dramatic changes in plant and animal life (Kassas, 1970). The ill-advised land use planning methods in these regions, coupled with severe natural perturbations, led to profound and devastating degradation. The net result is that arid regions are facing today more difficult problems than ever before.

In coastal deserts, these problems are augmented. These deserts are areas of attraction of human habitation and tourism. They are generally favored parts of the total desert regions lying further inland, due to the less adverse climatic conditions created by marine water bodies. The greater demographic pressures result in higher consumption rates, and lead to more severe land degradation and waste disposal problems.

Environmental Problems in Egypt

In Egypt, the Nile valley is the dominant factor, since for centuries it has represented an attraction for agricultural activities and formed a favorable environment for human occupation. Today, the populated regions represent only 4% of its total area. Population density is increasing dramatically in the Nile Delta and valley, and now it exceeds 1200 person/km^2. For this reason, the nation is paying considerable attention to the development of Egyptian deserts in order to redistribute the population and to release the notable pressure on cultivable land of the Nile valley. The demand for alternative productive land is always urgent because of this high rate of population growth. In order to cope with such demands, planning strategies traced short-term solutions aiming at producing higher economic profit for the nation, which lacked understanding of the proper application of landscape concepts compatible with special environmental dictates. This resulted in devastating effects on the natural resources and the social fabric.

Several studies have attempted to assess the evolution of the landscape of the northwestern coastal zone of Egypt (Figure 1.1) in order to evaluate its natural

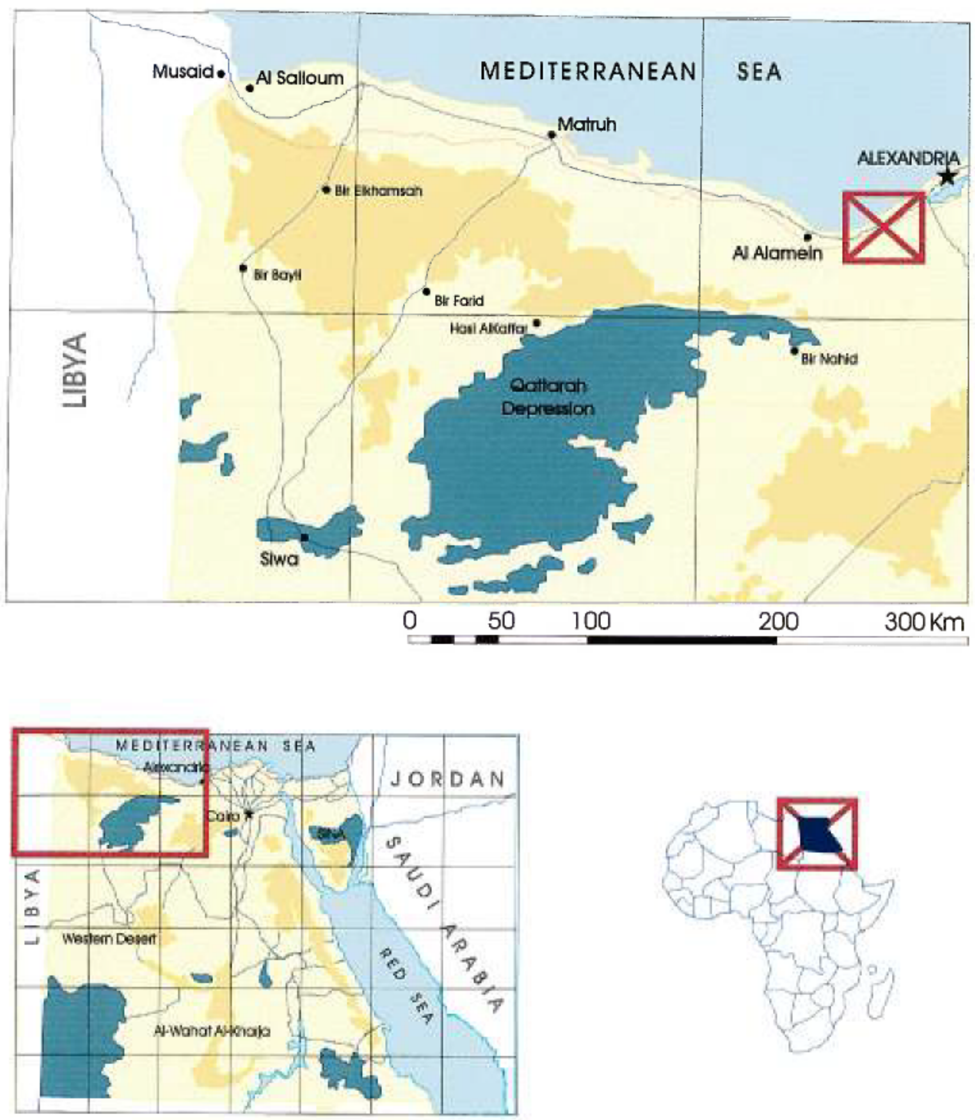


Figure 1.1.: Location of the northwestern coastal region of Egypt

resources and their capabilities to support development activities. However, the concepts of environmental planning, landscape ecology, and sustainable development, need to be considered. It was not until the beginning of the eighties that the environmental movement began to influence the studies and research concerned with planning and management of regional landscapes.

Two main trends may be identified in the landscape studies carried out in the northwestern coastal region of Egypt, professional applied studies and fundamental scientific research. The trend of professional applied studies is clearly reflected in the work of Ismail *et al* (1976) and Ismail (1978). The main objective which stemmed from the national goal, was to create a plan that contributes to the government's aim to "conquer the desert", to stimulate income and employment growth, to boost agricultural production and to enforce social stability in the region. This work concentrated on proposing a plan for developing the area by studying the needs and the possibilities of agricultural activities, different types of tourism, industry (quarrying, small industries, petroleum and oil extraction ...etc.), and public utilities. The methods relied on statistical comparisons, future projections and estimations. They generated several recommendations and conclusions for the development of the area extending from west of Alexandria city in the east to Sidi Barrani in the west (about 500 km long) (Figure I.1). Consequently, the scale of the study area was very general and not specific to designated sectors. The valuable contributions of these studies could have been more useful if they adopted a scientific approach and the ecological principles in dealing with fragile ecosystems of the region.

A more scientific appraisal of the environmental landscape management of the region was made by Ibrahim *et al* (1989), entitled "the development of environmental construction system in the western desert". It concentrated on analyzing cultural aspects of the region and of the inhabitants. The authors based their study on elements of social activities, cultural evolution, historical backgrounds, and population housing and vulnerable home construction in the pilot area of Burg El-Arab. They hypothesized that by knowing the organization of social communities and their limits and potentialities, planning and management decisions could be properly made. They based their analysis on the fact that, in a desert community, man is directly engaged with natural factors such as climate, topography, soil types, rainfall, underground water reserves, vegetation cover, and the communication facilities.

Fundamental scientific studies concentrated on the ecological features of the region. The earlier studies were concerned mainly with habitat types and vegetation distribution (e.g. Ayyad, 1973; Ayyad and Ammar, 1974; Ayyad, 1976; Ayyad and El-Ghareeb, 1982; Kamal, 1982 and 1988). More interdisciplinary studies were carried out on the structure and dynamics of ecosystems in two major research projects on "Systems Analysis of Mediterranean Desert Ecosystems of Northern Egypt" (see Ayyad and Le Floc'h, 1983). Studies which adopted a landscape approach included the work presented by Ayyad and Le Floc'h (1983) entitled "An ecological assessment of the renewable resources for rural agricultural development in the western Mediterranean coastal region of Egypt", which represented an endeavor of integrated mapping of El-Omayed test area (80 km west of Alexandria) (Figure I.1). At the time it was carried out, it was considered a unique scientific exercise to the western Mediterranean region, and indeed to other desert areas that represent important axes for socioeconomic development in Egypt. The presentation of results was more perceptible by decision-makers. Its major objectives were: (1) to propose various scenarios for the management of land resources and their consequences; (2) to indicate the consequences of implementation of various proposed scenarios of land resources in the study area; and, (3) to indicate the importance of taking into account several intercorrelated factors: predictable increase of population, socioeconomic changes, trends in land management, variability in dynamics of ecosystems, evolution of renewable resources, and variability of rainfall.

However, the socioeconomic factors were presented qualitatively and subjectively and were not fully used in the final analysis. Other attributes of direct relevance to touristic development such as the aesthetic attributes, were not taken into consideration. Although, aerial photographs were used to map land use change through three time periods, overlaying of land use/cover maps was not conducted. Instead, a transition matrix was presented to assess the degree of changes that have occurred in three land use categories: rangelands, orchards, and cropping areas.

In the late eighties, two other studies were conducted by Kamal (1988) and Salem (1989), both dealing with mapping natural vegetation and land use. The first study extended the main objective of mapping natural vegetation and land use to calculate potentialities, sensitivities, and suitabilities in order to conduct risk assessment. The author presented different scenarios for agricultural development and relied to a great extent on the methodological approach of Ayyad and Le Floc'h (1983). The ultimate aim was to propose different scenarios of development for a better man/environment interaction and compatibility. The intensive use of aerial photographs introduced a new technique for land use mapping and for change detection in the region. The second study used satellite remote sensing data in mapping the evolution of natural vegetation and land use in the region. The author introduced innovative visions of how to use satellite image processing techniques to classify natural vegetation and land use, and change detection was carried-out to delineate the area, amount, and the rate of change. These two studies (Kamal, 1988; Salem, 1989) were characterized by greater emphasis on vegetation and land cover classification. Their scientific background has greatly influenced their approaches and the selection of landscape elements.

A more recent study on "Landscape management of the western coast of Egypt: An environmental assessment" was carried out by Ayad (1996). It provided a change detection analysis of the landscape of Burg El-Arab pilot area (50 km west of Alexandria city), and applied the "carrying capacity and thresholds technique"[1] for analysis of urban and regional development possibilities. A two phase framework was devised for this study; a descriptive phase and an evaluative phase using the Geographic Information Systems (GIS) principles, and the interpretation of remotely sensed data and field surveys. The descriptive part was an attempt to map the changes of the landscape of the study area. This part was complemented by a change detection study. The changes in the physical environment during the past 40 years and the

[1] All of the uses of the general term of "carrying capacity" aim at relating the demand and supply of resources to sustain life. In land use planning, for example, the carrying capacity role is to define the ability of the natural environment to support growth or change. Two essential categories that often overlap are recognized where the concept is applied: environmental performance standards, and environmental threshold standards. Although performance standards analysis establishes some criteria to the type and location of growth, it usually does not claim that there is a specific limit to growth. However, the carrying capacity notion has been also applied to justify a growth limit (threshold) based on different criteria that are determined by the ability of resources to provide the services required and recover after peak demands without evidencing a serious deterioration in ambient environmental quality (Ayad, 1996).

possible consequences of the actual rate of transformation in landscape form were monitored. Two main conclusions were made from the descriptive phase. The first conclusion is that monitoring of environmental and man-made changes on a regular basis is needed so that the proper land management decisions can be made to minimize the negative effects of such changes. The second conclusion is that indigenous conditions and realities should be taken into consideration in any future development plans. Instead of imposing high capital-investment in housing, industries, or agriculture, which may not be compatible with the ecological and sociological existing conditions, development should aim at the use of local resources, simple water conservation techniques, and energy efficient planning and design.

The evaluative part of the study established a method of analysis and evaluation of proposed development schemes. The carrying capacity and thresholds concepts were discussed and applied through the definition of ecologically sound "solution space" in four dimensions: territorial, quantitative, qualitative, and temporal. The following conclusions were made from the evaluative part. (a) The applied method is simple, flexible and easily applicable, but a more elaborate form can be achieved by following it up with a threshold of cost-benefit analysis. (b) The method provides guidance on where and how developments should be directed at the lowest possible development, social and ecological costs. (c) While the carrying capacity and resilience of certain resources were generally estimated in this study, analyses conducted by ecologists, sociologists, and economists are needed in large-scale studies in order to achieve more accurate results. The following were more general conclusions. (a) By using the method of carrying capacity and thresholds limitations, not only the allocation of residential clusters could be decided, but also appropriate housing densities and quality may be achieved. (b) The selection of residential densities is not only a matter of social and economical preferences, but at the same level of importance, climatic and ecological needs have also to be fulfilled. (c) It is thought to be more efficient both environmentally and economically to design for high density model clusters integrated with adequate ratio of open space patches, which will function together as a large ecological network and reduce the effect of the development pressure on the ecosystem. (d) A scheme of water resource management and conservation is highly recommended within any proposed development program, and the merits of ancient water conservation techniques (e.g. cisterns and karms) should be promoted for more efficient use of run-off water.

Although the study by Ayad (1996) is the closest to an integrated approach of landscape ecology in the northwestern coastal region of Egypt, it was largely restricted to the application of some ecological concepts (the concepts of "carrying capacity" and "thresholds"). It did not attempt to examine the effects of other than the ecological factors in evaluating land use/cover changes. In this respect, the study did not adopt a holistic landscape approach[2], and was directed mainly to the evaluation of one land use type, the urban (residential) development, and the allocation of land to this activity as dictated by its carrying capacity.

To sum up, planning decisions in Egypt were often made by urban planners and agronomists whose interests were directed mainly to maximizing immediate economic gain without due attention to sustainable development for present and future generations. On the other hand, scientific research and studies were often mono-objective, concentrating mainly on either ecological, social or economic attributes of the landscape, and the results needed to take into account the full understanding of the structure, function, and dynamics of the landscape. Such understanding is necessary for decision-making concerning conservation and sustainable development of natural resources. This is needed especially in a fast developing landscape as in the case of the northwestern coastal land of Egypt. Therefore, the application of an integrated approach is recommended in analyzing the dynamics of the landscape and in extracting the major forces that shape up its structure. It is believed that by such analysis, a better understanding of the development of the northwestern coastal landscape of Egypt may_be achieved. Thus, the following questions may be raised. (a) What would be the model of analysis needed for elucidating the interactions between the landscape components as a basis

[2] One of the basic concepts of landscape ecology which makes it different from other disciplines in that it considers a specific tract of landscape as a whole including all its components (refer to CHAPTER II: DEVELOPMENT OF AN INTEGRATED APPROACH for more details)

for proposing alternative models of landscape planning in the western Mediterranean region of Egypt? (b) What are the ecological and social attributes to be taken into consideration in analysis for meeting this objective? (c) By testing the proposed model in a pilot study area, would it be valid for application in the western Mediterranean region? And (d) how could the model be modified for better application?

Conceptual Framework and Study Objectives

In the present study, concepts of landscape ecology are adopted in order to elucidate the manner in which a range of processes interact, and to provide a framework for the evaluation of human impacts on the environment, so that adequate management strategies may be developed. Understanding the nature and causes of the changing pattern across a range of specific landscape settings with time may offer opportunities for planners to provide serious consideration to the conservation of biodiversity and the enhancement of environmental quality in land management policies and programs (Comins *et al*, 1993; Simpson *et al*, 1994). Therefore, it is believed that the lack of a comprehensive understanding of the structure, function and the dynamics of the landscape can be overcome by the application of a basic concept that considers its different components in a coherent and interrelated manner. The concepts of landscape ecology constitute a major contribution to this field.

In this perspective, the present study attempts to integrate landscape[3] attributes in the analysis of its evolution, in which emphasis will be made on ecological, visual and socioeconomic aspects. The following are the main objectives.

- To review the bases and the concepts of landscape ecology, as developed by different schools of thought in order to reveal its benefits and to elucidate the manners by which it can contribute to the understanding of the landscape of the present study: (a) explanation of the basic terms "landscape" and "ecology" as defined by scientists in

[3] The term "Landscape" is used in its spatial appreciation meaning of what is on the land portion of the earth's surface. It describes the land cover/land use and the visual characteristics of the "natural" components, and the cultural aspects of the human population (refer to CHAPTER II:DEVELOPMENT OF AN INTEGRATED APPROACH for a detailed definition).

various disciplines, and as related to the structural, functional and dynamic aspects of landscape ecology; (b) explanation of the basic concepts of "multidisciplinarity", "holism", "steady state" as maintained by "homeostasis", "landscape stability", and "diversity" as applied to landscape ecology; (c) reviewing the ideas of major schools of thought as applied in landscape ecology: ecological planning, landscape design, and environmental planning; (d) examination of the notion of "sustainable development" as related to these schools of thought; and (e) evaluation of different research trends in landscape ecology, with special emphasis on comparing central European and North American trends.

- To establish a framework of an approach for analyzing and evaluating the landscape changes in arid coasts based on holistic considerations of ecological, visual and socioeconomic attributes, and to test its validity through application in a pilot area in the northwestern coastal land of Egypt.
- To assess the usefulness of landscape ecological concepts, and the application of the adopted approach in understanding landscape evolution of the northwestern coastal zone of Egypt, and in decision-making about the conservation and sustainable development of its natural resources.
- To elaborate a framework of a landscape planning model that is specific to the selected study area and to regions with similar conditions.

Structure of the Study

The study is structured in two main parts. The first part is dedicated to reviewing the concepts of landscape ecology, and to providing comprehensive information about the major schools of thought that have contributed to the evolution of landscape studies, such as ecological planning, landscape design, and environmental planning. In this part, Chapter II "DEVELOPMENT OF AN INTEGRATED APPROACH" provides a theoretical background including an overview of landscape ecology and its major schools of thought in relation to the concept of sustainable development. This chapter also includes an extensive survey of the tools and methodological techniques applied in landscape analysis. Chapter III "THE STUDY AREA" describes the study area in terms of its physical environment, and discusses the evolution of its landscape through an historical background survey.

The second part includes the application of the methodological framework to the selected pilot study area. Chapter IV "MATERIALS AND METHODS" deals with the description of data availability and preparation for further analysis. The analysis strategy based on the proposed integrated approach is also presented in this chapter. The results of the analysis are then presented in Chapter V "RESULTS". A general discussion of the results evaluates the benefits and the drawbacks of the adopted approach (Chapter VI "DISCUSSION"). In Chapter VII "TOWARD A MODEL FOR LANDSCAPE PLANNING" important elements in conducting landscape planning in the northwestern coastal region of Egypt are discussed and then used to develop a model for future application and management in the northwestern coastal land of Egypt. Finally, Chapter VIII provides "CONCLUSIONS" of relevance to the concepts of landscape ecology, the techniques applied in landscape analysis, and the drawbacks and merits of comprehensive analysis as adopted in the present study. It also extends some "RECOMMENDATIONS" addressed to scientists, planners, and decision-makers to make use of landscape ecology in future development of the northwestern coastal land of Egypt.

CHAPTER II: DEVELOPMENT OF AN INTEGRATED APPROACH

2.1.Theoretical background

Landscape ecology is an emerging science of the environment. It gives a way of perceiving landscapes in order to understand the interactions and the evolution of their natural and their human components. It provides planners and decision makers with valuable information about the nature of the problem they are dealing with. With its two component terms, landscape and ecology, it englobes the comprehensive horizontal perception of the spatial component of the landscape and the vertical biological interrelations and functions of its elements.

By the comprehensive understanding of the structure, function and dynamics of the landscape, decisions may be made to conserve its natural composition or to develop and utilize the resources in a sustainable manner, whereby man can use such natural resources under certain market and non-market cost/benefit limitations. Landscape ecology is thus devoted to provide planners and decision makers with the scientific material to be utilized as a basis for managing the human use of natural resources. In this chapter, an attempt is made to formulate an approach to understand the evolution of arid coasts landscapes, based on concepts of landscape ecology, and with emphasis on the role of the human dimension in understanding its changing elements.

2.1.1.Definitions and concepts

Before discussing the different approaches of the schools of thought which have contributed to the development of the concepts of landscape ecology, it is essential to define its component terms: "*landscape*", and "*ecology*", in order to avoid misunderstanding, especially concerning the word landscape which has been used by researchers with different backgrounds.

a. Landscape

The term “landscape” was introduced as a scientific-geographic term in the early 19th century by A. von Humboldt, the pioneer of modern geobotanics and physical geography, who defined it as “the total character of an earth region” (Naveh and Lieberman, 1984). With the rise of classical western geography, geology and earth science, the term’s meaning has been narrowed down to the characterization of the physiographic, geological and geomorphological features of the earth’s crust, as a synonym of “landform”. Naveh and Lieberman (1984) provided an historical review of the different meanings associated with the term "landscape" and its utilization in several disciplines. They concluded that it can provide the functional objects and processes of the individual disciplines dealing with plants, animals, and man, and their functional integration for present and future land use. Landscape commonly refers to the extensive area of land regarded as being visually distinct (Collins English Dictionary, 1994) or the land surface and its associated habitats at scales of hectares to many square kilometers. Steiner (1991) defines the term “landscape” in simple explicit terms as "the composite features of one part of the surface of the earth that distinguish it from another area"; it combines elements of landform and land cover (e.g. fields, hills, vegetation cover, water bodies and settlements) and encompasses land uses as transportation, housing, agriculture, recreation and natural areas. As mentioned earlier, the term "landscape" has been widely used with different meanings. But its original visual and aesthetic connotation is still being used by landscape architects and geographers in landscape planning and design. They are frequently more concerned with the scenic-aesthetic landscape perceptions than with its ecological aspects (e.g. Steiner, 1991; Laurie, 1986; Fabos *et al,* 1978; Zube *et al,* 1976; Smardon, 1983). In this context, the term "landscape" represents, in the present study, a spatial appreciation of what is on the land portion of the earth's surface. It describes, horizontally, the land cover/land use and the visual characteristics of the "natural" components, and the cultural aspects of the human population.

b. Ecology

During the 19th century, plant geographers, aquatic biologists and zoologists developed principles that gave birth to the discipline. The early 20th century saw a quickening and broadening of the ecological sphere to include the work of animal behaviourists, evolutionists, statisticians, animal geographers, and plant community ecologists (phytosociologists) (Forman and Godron, 1986).

Being less ambiguous, "ecology", the second term of landscape ecology, is the scientific discipline which studies the relationships between organisms and their surrounding environments. It is clearly defined by several authors. Ricklefs (1973) as quoted by Steiner (1991) defines "Ecology" as "the study of the reciprocal relationships of all living things to each other and to their biotic and physical environments", obviously including humans as living things. It is characterized by its vertical tendency to study the physical terrestrial and marine environment of the earth. It builds on the study of energy flow, material cycles, biotic diversity, and evolution. It also looks for factors with direct or indirect effects on an organism. A more comprehensive and detailed explanation and description of the science of ecology and its components and interests can be found in Forman and Godron (1986), and Odum (1989).

These definitions of the two terms, "*landscape*" and "*ecology*", refer to the structural, and indirectly, to the functional aspects of landscape ecology, but ignore its chronological aspect. However, it is conceivable that landscape ecology is also concerned with the dynamics of the land components, and therefore, extends the horizontal two-dimensional appreciation of the landscape to a third vertical dimension of energy flow and nutrient cycling, and includes as well a fourth dimension, time, by which chronological studies of the landscape, its dynamics and evolution, can be conducted.

Two more integrated views of landscape ecology are presented by Haines-Young *et al.* (1993). First is the view expressed by Vink (1983) that the objective of landscape ecology is to focus on the way in which a range of processes interact, and to provide a framework in which human impact on the environment can be understood so that actions and suitable management strategies can be developed. He considers landscape ecology in either a fundamental form (e.g. description and investigation of the phenomena, the processes and the relationships with regard to human and organisms) or an applied form (e.g. land evaluation, impact studies, and landscape design). Both forms are concerned with the understanding of the possibilities to use the natural phenomena for development in order to build a basis for resource planning, management and conservation (Naveh and Lieberman, 1984). The second integrated view of landscape ecology is introduced by Forman and Godron (1986). It incorporates the chronological aspect and defines landscape ecology as "the study of the structure, function and change in a heterogeneous land area composed of interacting ecosystems". Conceivably, the interactions within each ecosystem are included.

The chronological (dynamic) aspect of landscape ecology has recently been considered with view of understanding the interactions between human and natural landscape, and the consequences of human induced changes as well as their cost and benefit in terms of their ecological and economic values for the present and the future (Iverson, 1988; Ales *et al.*, 1992; Domon *et al.*, 1993). Hence, a major importance have been put in studying the ecological aspects and consequences of human activities. Fewer studies were oriented toward the understanding of the driving forces for such change. Such understanding of the nature and causes of changing pattern across a range of specific landscape settings with time may offer better opportunities for planners to provide serious consideration for the conservation of biodiversity and the enhancement of environmental quality in land management policies and programs (Comins *et al.*, 1993; Simpson *et al.*, 1994).

2.1.2.Basic concepts

Zonneveld (1990) in his article on the scope of landscape ecology reviews the theories and concepts of landscape ecology, and Petch and Kolejka (1993) discuss the conceptual bases for landscape studies. Accordingly, two related concepts form the scientific basis of landscape ecology: (a) landscape ecology is a transdisciplinary and multidisciplinary science, and (b) holism and systems theory. The first of these two concepts advocates that landscape ecology is the study of a tract of land, that requires many disciplines, and that it is not just a combination of the methods of various sciences but is an integration on a higher level that in turn influences, even embraces, other disciplines in basic philosophy and application (Naveh and Lieberman, 1984). This denotes that any scientist can hardly be a landscape ecologist *per se* without being a specialist in one of the component sciences.

The second basic concept, holism and systems theory, makes landscape ecology different from other disciplines in that it considers a specific tract of landscape as a holistic entity, including all its components. Holism, a philosophy formulated by Smuts since 1926 and continued by ecological scientists and philosophers, states that reality consists of wholes in hierarchical structure: atoms, molecules, minerals, compounds, organisms, populations, communities (e.g. human society), the world as a total ecosystem[1] (biosphere or ecosphere), the galaxy and the cosmos. Each of these is a whole system characterized by an organized set of relationships in a relatively "steady state". Such steady state is maintained by a mechanism called "homeostasis" or self-regulation by a set of positive and negative feedback factors that confer a dynamic equilibrium to the system. Another early consideration of this basic concept goes back to Carl Troll (Naveh and Lieberman, 1984). He regarded the landscape as fully integrated holistic entity in which the "whole" is more than the sum of its parts and that it should be studied in its totality. Landscape classification, is based mainly on this concept of holism. The importance of the concept in this respect is that, often the objects of study, like life and landscapes are so complex that real understanding gained by working from the basic elements upwards (i.e. agglomerative procedure) would be extremely difficult and time consuming, if it were ever possible, and that a divisive procedure would be more feasible, particularly in relation to regional planning. Besides, much improvement in

[1] Ecosystem is the complex of a community of organisms and its environment functioning as an ecological unit in nature (Merriam-Webster Dictionary, 1997)

land use capability analysis, and assessment approaches and methodologies has come from leading professional landscape architects dealing with the landscape in a holistic sense. Even though they may not formally use the term "landscape ecology", they are in reality making use of the comprehensive and integrated approach it represents. This aspect is discussed later in the present part in order to reveal a clear distinction of landscape ecological studies. Thus, McHarg (1969) started to develop techniques of designing with nature. Such development meets with the general tendency towards the provision of landscapes for recreation and for various kinds of conservation, based on ecological principles. New landscapes were created and designed with the benefit of the ecological processes and to provide a better living environment for human within his surroundings.

Another concept related to holism and homeostasis, is the concept of "landscape stability" (Petch and Kolejka 1993). According to this concept, landscape stability is considered to be a function of the spatial relationship between stabilizing and destabilizing elements of landscape. Stabilized elements are often species rich ecosystems (e.g. forest, range land, and hedgerows) which can be managed and regenerated, and are relatively stable (i.e. do not exhibit signs of erosion or nutrient loss). Destabilized elements are physically unstable and species poor (e.g. cultivated land). The spatial relationships between the two categories as expressed by a map of their distribution, are expressed in the framework of ecological stability. Assessment of such stability is based on the connectivity of stabilized elements and the isolation of destabilized elements, expressed in maps of stability analysis (Fahrig and Merriam, 1985; Forman, 1990; Forman 1995; Forman and Godron, 1986; Franklin and Forman, 1987; Hulshoff, 1995; Musick and Grover, 1991; O'Neill *et al*, 1988; O'Neill *et al*, 1996). Other determinants of stability are corridors, patches and other functioning elements of landscape. The appropriateness of land cover and land-management practices is another element of stability analysis. Such appropriateness is set against the optimum, the possible, and the inappropriate uses of mappable units of landscape (Petch and Kolejka 1993). These three hypothetical categories of land use are determined on the basis of abiotic land characteristics (geomorphology, landform, soil, hydrology and microclimate).

A new trend in landscape studies, is the study of landscape pattern by assessing the diversity of its units (Odum and Turner 1990). This trend is derived from the "diversity concept" applied to species by determining species richness and evenness. Accordingly landscape diversity may be defined as the richness (number of landscape units, cover types or habitats in a specified area) and evenness (the equitability of the abundance of each unit).

2.1.3.Major schools of thought

Distinction may be made between the main schools of thought by reviewing different landscape studies. A notable ambiguity prevails concerning the terms used to specify different environmentally oriented concepts. Generally, these notions are widely used by several researchers, not surprisingly, with different conceptualization and objectives. This confusion may be attributed to the important diversification of the scientific backgrounds involved in the subject that approaches the environmental problem each with its own specific way of thinking.

It is therefore important to discuss the ideas presented by different schools and notions that formed the foundation for the concepts of landscape ecology, in an attempt to define each with respect to its determining characteristics, and to its approach to the problem.

Almost all of the schools of thought that are interested in the environmental science have an ultimate aim of creating sustainable environments. That is to ameliorate the basis of natural resources in order to provide better living opportunities for the future generations, and furthermore, to improve the living conditions of the human population without destroying or undermining natural resources. Every school has its own view of "how to understand the behavior of the landscape phenomena" in order to achieve a concrete conceptualization to manage the landscape with a sustainable perspective.

Several schools of thought that have contributed to the development and to the emergence of concepts of landscape ecology can be distinguished. Among these are the schools of "*ecological planning*", "*landscape design*", and "*environmental planning*". The following is a brief account of the contribution of each school to the evolution and to the development of landscape ecology, and its role in the comprehension and the appreciation of the landscape, which will help in extracting major elements of significance to the formulation of the proposed approach.

a. Ecological planning

The major characteristic of "ecological planning" is its greater emphasis on the "biophysical" components of the landscape. It is generally interested in understanding the ecological factors and processes that occur. It explains landscape changes as functions of the components of its ecological systems. Based on these principles, ecological cartography is considered as an important tool in planning, and aims to classify the landscape into discrete elements and ecosystems. It is considered as a mean to analyze and represent the "biophysical" components of the landscape. It also provides an evaluation of the constraints and the potentialities of territories in favor of specific land utilization (Giliomee, 1977; Walker and Norton, 1982). Different interrelationship studies are widely conducted, and results may be presented as suitability classes to certain activities.

The human factor, on the other hand, is considered, to some extent, as an impact on the biological processes (i.e. biological structure and function) and is fairly taken into consideration, but few attempts are made to understand socioeconomic, political, and historical factors. The "ecological planning" is object oriented. It takes into consideration the sum of the "biophysical" characteristics in the decision making process (Domon, 1990). Thus, in general, the "biophysical" characteristics of specific landscapes are considered as the absolute and the conclusive factors in the management perspective and the defining elements of planning for possible land utilization. The cultural components (socioeconomic and political) of the landscape are rarely taken into consideration. This may be attributed to the fact that the scientific background of researchers in ecological planning are generally ecological, agronomic, or biological. However, it is important to note that the "ecological planning" has given the impetus to landscape ecology to emerge. As will be discussed later, ecological planning has greatly influenced many scientists who may be considered as landscape ecologists. Thus, one major tendency of studies of landscape ecology, as viewed by Domon and Leduc (1995) is ecological.

b. Landscape design

In contrast with the "ecological planning", "landscape design" gives more weight to the values of landscape that directly influence the human senses and life. It is directed to design and to plan landscape elements in terms of primarily creating spaces for human living. Landscape planning and design are of specific concern to landscape architecture which attempts to match its goals with the problems and needs of society. Ekbo (1950) defined landscape architecture as:

> *"... the establishment of relations between building, surfacing, and other outdoor construction, earth, rock forms, bodies of water, plants and open space, and the general form and character of the landscape; but with primary emphasis on the human content..."*

It is therefore remarkable that landscape planning and design have been greatly influenced by landscape architecture. Its most important function is to create and preserve beauty in the surroundings of habitations, and it is also concerned with promoting the comfort, convenience and health for man. Recently, broader responsibilities for landscape architects have been identified, and they became involved with larger regions and with more open understanding of the natural processes, human factors, and values (Laurie, 1986).

The aesthetic characteristics of the landscape were widely identified by landscape architects and geographers. It formed also a field of interest for planning and designing landscapes. Their aesthetic object can be regarded as the interaction of subject and object in the process of experiencing the landscape.

From this point of view, landscape design was more oriented towards the quality of sensed landscape and human reaction and interaction to observe and to appreciate its components. This paradigmatic aesthetic thought is largely dominated by an horizontally, spatial perception of the land surface, and usually the ecological dimensions and processes are marginally handled. Not long ago, a significant appreciation of the "bio-physical" characteristics of the landscape were taken into consideration; the works of Bourassa (1991), Laurie (1986), Lyle (1985), and McHarg (1969) are examples of principles, methods and philosophical accounts on the understanding of human and natural ecosystems.

The role that landscape design have played in the development of the concept of landscape ecology, however, is not negligible. It extended the vertical heterogeneity of the ecological view to include factors of importance to planning and managing natural resources. These factors, mostly of human dimension, in general, and specifically of aesthetic aspects, have been recently taken into consideration with certain limitations, as it will be indicated later on.

c. *Environmental planning*

The examination of texts such as those by Lusser (1993), Marshall (1993), Marsh (1983 and 1978), and Jacobs (1970), indicates that “environmental planning” touches directly on the environmental concerns of the human societies. It covers an enormous variety of issues ranging, for instance, from human health, to land, air, and water pollution, and to global population and food supplies. Domon (1990) concludes that “environmental planning” emphasizes the environmental and the social effects produced by specific utilization or projects, with a general perspective to tackle both social and biophysical components. In this sense, “environmental planning” seems to be more definitive despite the difficulties that may be encountered in classifying trends of research and schools of thought.

The “environmental planning” practices have greatly influenced landscape ecological concepts. It gave the opportunity for landscape ecology to regard "natural" and "cultural" phenomena with a global perspective and to address all possible information to a whole range of actors from individuals to both public and private sector organizations.

With its very large scope and, in some cases, objectives, "environmental planning" may be considered as a multitude of many disciplines and thoughts. It includes several scientific backgrounds that range from political to biological science which have greatly influenced the definition of terms, goals, objectives, and practices. This multidisciplinarity was the major factor that gave birth not only to several research trends but also to various schools of thought and philosophical appreciation in landscape ecology (Naveh and Lieberman, 1984).

2.1.4.Sustainable development as related to landscape schools of thought

Sustainable development is a philosophical conceptualization of achieving the balance between the "natural" resources and the human needs and ambitiousness. It aims to achieve harmony between natural resources and humanity in the present and the future. It is considered as the ultimate objective of environmental and socioeconomic disciplines that tackle developmental issues and problems.

Although the term "sustainable development" did not rise until the eighties, its conceptual framework has been often considered in management and planning practices and methodologies. Its goal of achieving the needs of present and future generations promotes the responsibility of maintaining social justice, cultural diversity, and ecological integrity (Gariépy *et al.*, 1990).

When applied in the environmental context, sustainable development becomes the principal goal to be achieved despite the differences between the three schools of thought: ecological planning, landscape design, and environmental planning, in the appreciation of factors, elements and components that are considered as the driving forces of landscape change and dynamics. Sustainable development gave the impetus for perceiving values, not only ecological but cultural as well in which socioeconomic aspects, market and non-market costs and benefits have to be evaluated in order to achieve the best balanced human/nature interaction.

To sum up, it may be concluded that landscape ecology has its conceptual, methodological, and philosophical way of perception and handling of landscape issues. Occasionally, however, the tendencies that emerged, and that adopted such concepts, have given more weight to issues that may (or may not) be of essential value to understanding the landscape. Such tendencies risk to give doubtful information, recommendations, and unpredictable results. They stem from their own scientific background, which have greatly influenced their approach to landscape ecological objectives. It still remains questionable whether, for instance, much of the research in landscape ecology has promoted the understanding of landscape dynamics, and whether such research has achieved its major objective of its application in planning and management of natural resources.

2.1.5.Evaluation of research trends

Landscape ecology has been greatly motivated and guided by the different schools of thought. It may be noted that there is no clear boundary that differentiates each. It is also notable that studies such as the "Design with nature" of McHarg (1969) and others are being treated and classified differently by several authors. Laurie (1986), for instance, puts the "landscape architecture" on the top of environmental practices, and considers works of McHarg as one of its branches. In his point of view, it represents the way in which planning the landscape forms a positive process to fit land uses to the most suitable land and to prevent ecological loss of waste of natural resources. Furthermore, Domon *et al.* (1993) have noted this uncertainty of significantly differentiating between the "ecological" and the "environmental" planning. Even though, for example, he argues that it is clear to identify environmental planning by its character of mediation between actors, and ecological planning by its linkage to biophysical objects and phenomena exploitation, the terms can be widely used in heterogeneous composition of tendencies and schools. Thus, any attempt to classify landscape schools of thought could lead to a confusion, even if it is clear sometimes to identify research trends concerning landscape and planning and management of human use of natural resources.

If we review the evolution of landscape ecology from its first articulation by the German biogeographer Troll (Naveh and Lieberman, 1984) in the early forties, through the development of the environmental sciences stimulated by the "environmental crisis" in the seventies, to the advancement of the concept in the eighties, it becomes evident that several practices have adopted the concepts of holism and ecological integration in planning and managing landscapes without any mention of the term "landscape ecology". It is therefore notable that landscape ecological concepts aim to combine ecological thinking and cultural appreciation in order to understand landscape spatial composition and evolution. It is not a way of accumulation of information but rather an attempt to achieve a comprehensive approach to characterize landscape features by anatomizing its components, and therefore be qualified to describe remedies and prevention. In this sense, two main general trends of research may be identified. The first trend tends to be influenced by ecological spatial analysis. This is clear, for instance, in most studies of landscape ecology in North America, which emphasize the horizontal aspect of the landscape and are oriented towards the analysis of corridors, patches, and matrix and networks (Forman and Godron, 1986), and on ideas of climax and succession which relate to smaller scales and longer periods (Petch and Kolejka, 1993). On the other hand, the central European studies, representing the second trend of research, stress the interrelationships between the physical, biological and cultural aspects of ecological systems, and use mapping and description of landscape patterns for planning purposes.

Central Europe landscape ecology has a long history (Naveh and Lieberman 1983), in contrast to its short history in North America (Forman and Godron, 1986). A major conceptual stimulus came from the German geo-ecological school and the Soviet school. These schools introduced a strong ecological element and laid foundations for current ideas and methods of landscape ecology which integrates physical and ecological (ecosystem) approaches to landscape study. On the other hand, North American landscape ecologists (and some in Western Europe) have been concerned mainly with factors which control the location and the spatial and temporal activity of biota, and the influences of organisms on the landscape pattern (Forman and Godron, 1986; Forman, 1990; Naveh, 1995; Naveh and Lieberman, 1983; Schreiber, 1990; Zonneveld, 1990). Thus, the approach in central Europe is largely descriptive and global, and in North America it is rather analytical (Lavers and Haines-Young, 1993).

2.1.6.The human dimension

By reviewing studies such as Naveh and Lieberman (1984), Forman and Godron (1986), Hills *et al.* (1970), and Haines-Young *et al.* (1993), it becomes obvious that the ecological dimension of the landscape is dominating the analysis. The major phenomena of landscape dynamics are generally tackled with the background of understanding the ecological processes. To present, the human factor in landscape dynamics has been dealt with in a complementary manner, although it is, often, the overriding "factor", particularly in the "human-altered" landscapes. Most studies on the human impacts causing landscape changes tend to deal more with the changes caused by the "bio-physical" factors, and to study the effects of only specific human activities on the natural components of the landscape (Odum and Turner, 1990; Ispikoudis *et al*, 1993; Iverson, 1988). However, the main objective of landscape ecology, as mentioned formerly, is to help in creating a sustainable environment. The aim of such sustainability as stated by Gariépy *et al.* (1990) is dedicated to the type of development that answers the needs of the present generations without putting into uncertainty those of the future. It may, therefore, be concluded that any planning and management activity should be oriented directly to achieve better human life for present and future generations and not only for the sake of the preservation of natural environment, landscape, and natural resources. However, dealing with the human dimension may face difficulties and complexities due to the unpredictability of the human behavior which stems from his social history and interactions. The degree of appreciation and the way of perception of market and non-market values may also differ widely from one society to another. These cultural characteristics play a great role in driving man to act on the landscape. Culture refers to the total way of life of any society; it is what distinguishes human from other creatures. It is a result of the unique mental ability of man to assign to things and events certain meanings. Therefore, it is clear that different cultures see the physical environment in different ways. Naveh (1995) have traced this anthropological concept of culture based on socially transmitted behavior, rather than biologically determined one. With this sense, it can be considered that all human inhabited, influenced, or modified landscapes are the tangible products of interactions between nature and cultures (Altman and Chemers, 1980; Smardon, 1983; Naveh, 1995). In brief, this heterogeneity in different culture characteristics may produce different types of planning and management strategies and approaches (Morey, 1985).

Reviewing the major tendencies in the evolution of landscape ecological concepts, (e.g. Forman and Godron, 1986; Naveh and Lieberman, 1984; Zonneveld, 1990) it may be noted that the notions on ecological factors such as species diversity, successional stages, connectivities and landscape stability, are the "core" elements of landscape evaluation and characterization. Cultural elements vary in each of them. For instance, Forman and Godron (1986) put greater emphasis on structure (patches, corridors, and matrix and network), function (connectivity, landscape resistance, and interactions) and dynamics of landscapes (stability, transitions, and forces of change). With their horizontal view of the landscape they hardly included the human factors in their management elements and strategies and classified different landscapes according to the weight of human intervention. Zonneveld (1990), on the other hand, presented his understanding of the landscape in both the horizontal aspect, representing the land use/land cover heterogeneity and land units, and the vertical heterogeneity expressed by land attributes. He presented the cultural dimension as a complementary factor that may help in understanding the landscape. It can hardly be seen in his text a fundamental appreciation of the human role in shaping the landscape. Finally, Naveh and Lieberman (1984) presented a more concrete explanation and definition of the role of landscape ecology, but a gap can be found between the theoretical and the applied parts of their book which indicates that more comprehensive work has to be done to correlate theoretical and applied aspects (Domon and Leduc, 1995).

One may then conclude that the essence of the main concepts of landscape ecology is the ecological appreciation of the changes in the bio-physical environments, despite the current interest in studying the transition of, what Bridgewater (1993) reviewed from Westhoff (1971), landscape types, from "natural" and "semi-natural" landscapes to human settlements and activities or "agricultural" and "synthetic" landscapes. Other attributes, especially cultural ones, are regarded as complementary subjects. Knowing that the landscape changes are, in general, resulting from decisions made by human actors that exhibit certain social behavior and dynamics throughout the years, it is primordial to assess the real contribution of the cultural dimension in landscape characterization in order to understand its evolution.

With this background of the above-mentioned review, a framework is proposed for the study of landscape of the pilot area of the northwestern coastal (NWC) region of Egypt, which is based primarily, as discussed later in this chapter, on the main concepts of landscape ecology, holism and transdisciplinarity. This will be carried out in order to assess their potentialities in analyzing arid coastal landscape of a developing country.

The two basic concepts of landscape ecology, multidisciplinarity and holism, call for an integrated approach to the study of landscape. This necessitates the integration of disciplines of relevance to landscape ecology and the treatment of landscape as a whole. Ideally, this has to be performed by coordinated teams of these disciplines in the same or in different institutes. Such ideal performance can hardly be achieved, particularly in developing countries due to the lack of expertise, scientific management and financial support. But the "systems approach" does not necessarily exclude the possibility of the identification of the discipline of major interest to the objective of a specific case study, provided that some degree of integration of other relevant disciplines be secured. It is then a question of the "level" of multidisciplinarity and holism, a matter, which is expressed in most landscape studies that often focus on certain aspects more than others. Accordingly, multidisciplinarity and holism can be realized in the present study by, first focusing on the landscape attributes that are most related to the ecological, socioeconomic and developmental driving forces of landscape dynamics in the study area, making use of the available information and data recorded on the changes in these attributes in the present study. The second requirement for applying these two concepts in the analysis of the landscape of the study area is to integrate the collected information and data by applying multivariate and statistical treatments. In this respect, it is to be stressed once again that the cultural aspect, in particular, has not been adequately integrated in most landscape studies. Conceivably, the natural attributes of landscapes (e.g. soils, topography, micro-climate, vegetation, etc.) play a major role in explaining the human derived land uses, because naturally favorable attributes often dictate the selection of a particular landscape for a specific use, while on the other hand, socioeconomic changes can alter landscape patterns and processes; this cultural dimension has generally been piecemeal studied in landscape ecological assessments. The common trend is to deal mainly with natural variables of vegetation, soil, wildlife, water resources, etc. without extensive consideration of the relationships with socioeconomic and sociopolitical variables.

Furthermore, physical characters of the landscape can be identified by its visual attributes. This relates to the fact that planning and management decisions, culture interaction, and natural processes lead to physical changes that will eventually be seen in the landscape. This confirms that the landscape is a revelation of all dynamic relationships between all its cultural and natural aspects.

The desire for valid means for quantifying the scenic characters of the landscapes has increased substantially with the development of land use planning and its requirement for environmental data on which to base land use decisions (Litton *et al*, 1974; Zube *et al*, 1976; Smardon, 1983; Jackle, 1987). Scenic landscapes are a major source for human enjoyment and in some cases have been the object of direct public action to preserve their quality (Bishop and Hulse, 1994; Dearden and Sadler, 1989; Fabos et al., 1978; Itami, 1989; Moss and Nickling, 1989). Advancements in this area, particularly in methodology, are similar to developments in other research areas which collectively contribute to the field of environmental management. However, while the opportunity exists for the incorporation of landscape or scenic assessment data in a range of environmental planning scenarios, the demand for this information is poor and ill-defined (Moss and Nickling, 1989). This raises the question as to the degree to which existing procedures have the capacity to incorporate, or relate to, information on naturally occurring events and may also be the outcome of any conservation or management strategies developed (Crawford, 1994; Moss and Nickling, 1989; Thorne and Huang, 1991; Smardon and Fabos, 1983).

2.2.Tools for landscape analysis

2.2.1.Remote sensing as a source of data

Remote sensing techniques have the potential to overcome the manpower and fiscal restrictions that now limit large-scale landscape ecological surveys, and recent studies have demonstrated their utility in assessing physiognomic vegetation distribution (e.g. Benson and MacKenzie, 1995; Metzger and Muller, 1996; O'Neill *et al*, 1996; Qi, and Wu, 1996; Salem, 1989). Visible and near-infrared multispectral images are the most useful data currently available to examine vegetation pattern and corresponding ecological processes.

The problem of relating spatial data to the conventional ground based measurements arises; however, to make use of remote sensing data it is essential to understand the correspondence between scene radiance as recorded in multispectral images and parameters. The radiance measured by a multispectral image also is influenced by various factors that are unrelated to the materials on the ground such as instrumental sensitivity and drift, viewing and illumination geometry, atmospheric backscatter and absorption, and the geometric orientation of surface elements (including topography) within the scene. With these factors taken into account, it is possible to interpret the light reflected from a surface in terms of materials and their mixtures.

Satellite images cover spatial scales from few of meters to hundreds of kilometers. One challenge is to connect observations of objects in the field to the measurements made by the smallest resolution elements of the multispectral images. This requires understanding the reflective properties of the landscape components at the field scale. The next challenge is to extend ecological observations from local areas to larger regions based on the properties measured by the images. By this, images become a unique vehicle for exploring regional patterns of landscape attributes, providing new ecological insights. There are three main approaches to the problem of estimating type and abundance of landscape components from remotely sensed images: (a) the calculation of indices that may be related empirically to the parameters of interest; (b) thematic mapping, or statistical methods of image classification; and (c) spectral mixture analysis (Salem, 1989).

Vegetation index and classification techniques have been primarily used to map vegetation in agricultural or forest lands where the argument can be made that there is a single scene component or class represented in at least some pixels. However in the sparsely vegetated areas this is rarely the case, and index and classification techniques have been shown to perform less well (Salem, 1989). In desert shrub environments, thematic classes correspond to characteristic suites or mixtures of components that occur in preferred proportions and certain illumination geometries. The radiance recorded in an image pixel may be mixed from both soil and vegetation. And because soil and vegetation can theoretically mix in any proportion, there exist (in theory) an infinite number of classes. Thus rules must be applied to designate thematic classes for many scenes.

Spectral mixture analysis transforms radiance data into fractions of a few dominant end member spectra which correspond to scene components. Fraction images depict the mixing proportions of these end member spectra and thus via calibration to field data, the mixing proportions of the scene components.

Several studies were carried out in the western coastal desert of Egypt for monitoring changes in rangeland vegetation cover (e.g. Richards 1987; Salem 1989) applying different remote sensing techniques using visible and near infrared spectral wave bands. The underlying similarity of many of the remote sensing techniques as applied to arid lands were emphasized, and their individual merits were discussed. The satellite image data were obtained from Landsat-MSS[2] (80x80m) and SPOT-HRV[3] (20x20 m) of representative sectors, and land-held radiometer field data were taken for individual soil types. These studies emphasized that although remote sensing techniques may be used for the detection of green vegetation in arid lands, the results were different from those obtained in temperate environments, mainly because the land cover in arid regions is dominated by the spectral properties of the soil due to the sparse vegetation. The influence of vegetation on the overall reflectance is consequently of a secondary nature. The reflectance of the soil in the infrared wave band can be greater than that of even a dense green vegetation canopy. Another factor which characterizes arid regions is that vegetation is green only for a short period during the year, after which annual species die off and perennials become yellow. The red wave band reflectance then increases as chlorophyll absorption declines while the infrared wave band reflectance may remain more or less the same and possibly increases, meanwhile the dormant plants cast shadows on the surface, thereby reducing overall reflectance.

In summary, it can be concluded that, in the regional scale, to reasonably succeed in the detection of the natural vegetation and the other sparse land use/land cover classes in an arid environment, it is important to consider high-resolution remotely sensed imageries as data collection method. This should always be verified by consecutive field visits to collect ground-truth information about suspicious areas.

2.2.2.Data management

This step involves data base functions as validation, editing, updating, etc., as well as cartographic processes as digital mapping validation, editing, transformation,

[2] Landsat Multi Spectral Scanner
[3] SPOT High Resolution Visible

raster and vector conversions, etc. The application of electronics and computer science to the production and management of the spatial information is a real technological revolution. This technology affects all the phases of the process: the way to collect and process the information, the printing and editing utilities, and even the hardware in which the georeferenced information is materialized. The technological keys of these developments are focused on the digitization of the graphic information and therefore, of its computer-based processes, and on the display of satellite images with clearer resolutions. Technological advances, such as computerization, remote sensing and geographic information systems (GIS) improve the geographical knowledge and the accuracy of its representation.

Objects existing in geographic space may be described by two types of information, related to their location in space, to which the term "spatial data" is restricted, and which identifies other properties of the object apart from its location, and is termed "attribute data". Attribute data may be measured according to nominal, ordinal, interval and ratio scales. It is these attributes which are usually the concern of the non-spatial scientist, who uses them to draw up classifications of objects according to the attribute values they possess. The geographer, however, is also concerned with classification according to spatial criteria. Dangermond (1983) notes the importance quality of variable independence in the representation of such data: attributes can change in character while retaining the same spatial location, or vice versa. A GIS will frequently employ different database management strategies for the handling of these two types of information. Most systems use one of the two fundamental map representation techniques: vector and raster. With vector representation, the boundaries or the course of the features are defined by a series of points that, when joined with straight lines, form the graphic representation of that feature. The points themselves are encoded with a pair of numbers giving the X and Y coordinates (such as latitude/longitude). The attributes of features are then stored with a traditional database management software program. On the other hand, with raster systems, the graphic representation of features and their attributes they possess are merged into unified data files. Features are not defined, but rather the study area is subdivided into a fine mesh of grid cells in which we record the condition or attribute of the earth's surface at each point (cell). Each cell is given a numeric value which may then represent either a feature identifier, or a qualitative attribute code of a quantitative attribute value. In the raster display, there is a grid of small cells called pixels (picture elements). Pixels can be made to vary in their color, shape or gray tone.

Raster systems are typically data intensive since they must record data at every cell location regardless of whether that cell holds information that is of interest or not. However, the advantage is that geographical space is uniformly defined in a simple and predictable fashion. As a result, raster systems have substantially more analytical power than their vector counterparts in the analysis of continuous space, and are thus ideally suited to the study of data that are continuously changing over space such as terrain, vegetation biomass, rainfall and the like. The second advantage of raster is that its structure closely matches the architecture of digital computers. As a result, raster systems tend to be very rapid in the evaluation of problems that involve various mathematical combinations of the data in multiple grids. Hence they are excellent for evaluating environmental models such as for soil erosion potential and forest management suitability. In addition, since satellite imagery employs a raster structure, most raster systems can easily incorporate these data and some provide full image processing capabilities.

While raster systems are predominately analysis oriented, vector systems tend to be more database management oriented. Vector systems are quite efficient in their storage of map base data because they only store the boundaries of features and not what is inside those boundaries. Because the graphic representation of features is directly linked to the attribute database, vector systems usually allow one to roam around the graphic display with a mouse and inquire about the attributes of any displayed feature: the distance between points or along lines, the areas of regions defined on the screen , and so on. In addition, they can produce simple thematic maps of database queries. Compared to their raster counterparts, vector systems do not have as extensive a range of capabilities for analyses over continuous space. However, they do excel at problems concerning movements over a network and can undertake the most fundamental of GIS operations that will be sketched. It is the simple database management functions and excellent mapping capabilities that make vector systems attractive.

2.2.3.Data manipulation and analysis

This step includes query functions, spatial query, geographical analysis and modeling. As Martin (1991) hints:

> *"Manipulation and analysis represents the whole spectrum of techniques available for the transformation of the digital model by mathematical means."*

These are the core of a GIS, and the features which distinguish GIS from CAC (Computed Aided Cartography). A library of data processing algorithms is available for the transformation of spatial data, and the results of these manipulations may be added to the digital database, and incorporated in new visual maps. Using these techniques it is possible to change deliberately the characteristics of the data representation in order to meet theoretical requirements. It is equally possible to mishandle or unintentionally distort the digital map at this stage

Assessments of patterns of landscape structure and function are based on spatially distributed ecological data which are necessarily recorded at a variety of spatial and temporal scales. These data, particularly those derived from remotely sensed images, may be more efficiently stored and more effectively analyzed using a GIS. Of particular importance to landscape ecology is the need for developing GIS that handle landscape ecological data of a variety of scales in a hierarchical fashion. Such systems should support the following functions: providing a database structure for efficiently storing and managing ecosystems data over large regions; enabling aggregation and disaggregation of data between regional, landscape and plot scales; improving remote sensing information-extraction capabilities; and providing input data/parameters for ecosystem modeling.

The fundamental classes of operations performed by GIS have been characterized as a "map algebra" (Berry, 1987; Tomlin 1983) in which context primitive operations of map analysis can be seen as analogous to traditional mathematical operations. A distinction is then made based on the processing transformation being performed. These "classes of analytical operations" are divided into reclassification, overlay, distance and connectivity measurement, and neighborhood characterization, which are, interestingly, independent of raster and vector representations of the data.

Reclassification operations transform the attribute information associated with a single map coverage. This may be thought of as a simple 're-coloring' of features in the map. For example, a map of population densities may be reclassified into classes such as 'sparsely populated' or 'overcrowded' without reference to any other data. Overlay operations involve the combination of two or more maps according to Boolean conditions, and may result in the delineation of new boundaries. In such cases it is therefore essential that the spatial and attribute data are a correct representation of the real world phenomena. An example would be the overlay of an enterprise zone on to a base of census wards. This would be appropriate to determine the ward composition of the zone, but may not allow an accurate estimate of the population falling within it, as there may not be exact coincidence of the boundaries. Thus the operation is appropriate only if the intended interpretation of the data is meaningful. Stow (1993) recognizes three approaches for integration of GIS and landscape models in ecological studies, using the overlay techniques: using GIS to summarize representative or "average" conditions which are used as parameters or states for patch (e.g. meter square) models; using GIS to specify parameters and states for model simulations of each patch, with no interaction between patches; and using the GIS to specify parameters and states for model simulations of each patch, with interaction between patches.

Distance and connectivity measurements include both simple measures of inter-point distance and more complex operations such as the construction of zones of increasing transport cost away from specified locations. Some systems will include sophisticated networking functions tied to the geographic database. Connectivity operations include, for example, view shed analysis, involving the computation of inter-visibility between locations in the database. Neighborhood characterization involves ascribing values to a location according to the characteristics of the surrounding region. Such operations may involve both summary and mean measures of a variable, and include smoothing and enhancement filters. These techniques are directly analogous to contextual image classification techniques to be found in image processing systems.

Statistical methods of data classification include maximum-likelihood, clustering, and discriminant analysis and methods based on principal-components analysis. The objective of image classification is to link image spectra to dominant scene components or to characteristic mixtures of components. It is assumed that spectrally similar data will describe thematically similar elements within a scene. It is also assumed that for each pixel there is a dominant scene components, or at least a unique and identifiable suite of components that are present in distinctive proportions. Maximum likelihood classification (MLC) was applied to SPOT-HRV data of the North Western Coastal region of Egypt (Salem 1989) to study the vegetation and land use patterns, and yielded classification accuracy of about 85%.

Stow (1993) remarks that raster-coded GIS are inherently compatible with digital satellite image data. The major advantage of raster structure for landscape ecology applications is their representation of continuous or surface type data, such as elevation and vegetation cover. On the other hand, vector data structures are effective for ecological management studies, and provide a more efficient structure for data storage. While spatial overlay modeling may be more straightforward with raster structures, the results of recent attempts at integrating GIS with spatially explicit models of landscape processes (e.g. surface run-off models) suggest that vector coding provides a powerful structure for achieving this integration. Examples of cartographic modeling in GIS can be found in Bitterlich *et al.* (1993), Katz (1993), and Theobald and Gros (1994). Such models were applied on data captured at different points in time in order to assess the changes in landscape of the study area during the last few decades.

2.2.4.Output and reporting

This involves the export of data from the system in computer and human readable form. It is at this stage that the user of a digital map database is able to create selectively a new analog map product by assigning symbology to the objects in the data model. This technique involves many of those conventional cartography, which seeks to maximize the amount of information communicated from the map maker to the map reader; it also includes tables that summarize the interrelationships that exist between the changes that have occurred in different landscape components. The nature of the digital model at this stage has a major impact on the usefulness of any output created as it represents the way to communicate and to deliver research results and ideas to the public and to decision makers.

The adoption of the multidisciplinarity and holism concepts as a framework for the present study (discussed earlier in this Chapter) may be realized by applying the above-mentioned tools for landscape analysis. Remote sensing would enable the monitoring of changes in the ecological, socioeconomic and visual attributes taken into consideration. It would also be of advantage in detecting the changes in sparse land-use/land cover classes characteristic of the arid environment of the study area. The GIS will be applied here as a tool of organizing (validating, editing, and updating) the information generated by field surveys and remote sensing, as a prerequisite towards the integration of the selected landscape attributes. Finally, the realization of this integration is to be achieved by applying the tools of data manipulation and analysis, including image processing, classification of land cover, different measurements and calculations, and statistical treatments. In the following chapter a description of the selected study area is carried out in order to explain different landscape attributes and to discuss the evolution of its natural and social aspects. Which will help in the extraction of different landscape attributes, and highlight the major axis of the analysis procedures.

CHAPTER III: THE STUDY AREA

3.1.Location

The study area is a part of the northwestern coastal land of Egypt which averages about 15 km in width, and in some places it exceeds 30 km. The pilot study area extends from Burg El-Arab in the east (about 45 km west of Alexandria) to El-Hammam (about 65 km west of Alexandria) in the west, with a depth from the Mediterranean shoreline of about 20 km inland. It is located between longitudes 29°23'E and 29°33'E and between latitudes 30°49'N and 30°58'N (Figure 3.1).

3.2.The Physical environment

3.2.1.Physiography

The North-Western coastal zone of Egypt, where the study area is located, may be distinguished into two main physiographic provinces: an eastern province between Alexandria and Ras El-Hikma (about 230 km west of Alexandria) and a western province between Ras El-Hikma and Salloum. The landscape is distinguished into a northern coastal plain and a southern tableland (Salem, 1989). The coastal plain is wide in the eastern province (where the study area is located), and is characterized by alternating ridges and depressions running in a nearly East-West direction. The ridges vary in altitude and are dissected by many shallow erosion valleys. Some of these valleys discharge water in the Mediterranean, the others in depressions (Ayyad, 1978). The ridges are formed of limestone with a hard crystallized crust, and vary in altitude and lithological features according to age. The most prominent are the coastal, Abu-Sir, and Gebel-Mariut ridges. The Abu-Sir ridge is separated from the coastal ridge by a depression with a mean surface elevation of 5 m above sea level and a width which varies between 300 m and 1 km. It is filled with calcareous formations, highly saline in places and formed almost totally of oolitic grains in certain localities. The depression between Abu-Sir and Gebel-Mariut ridges is

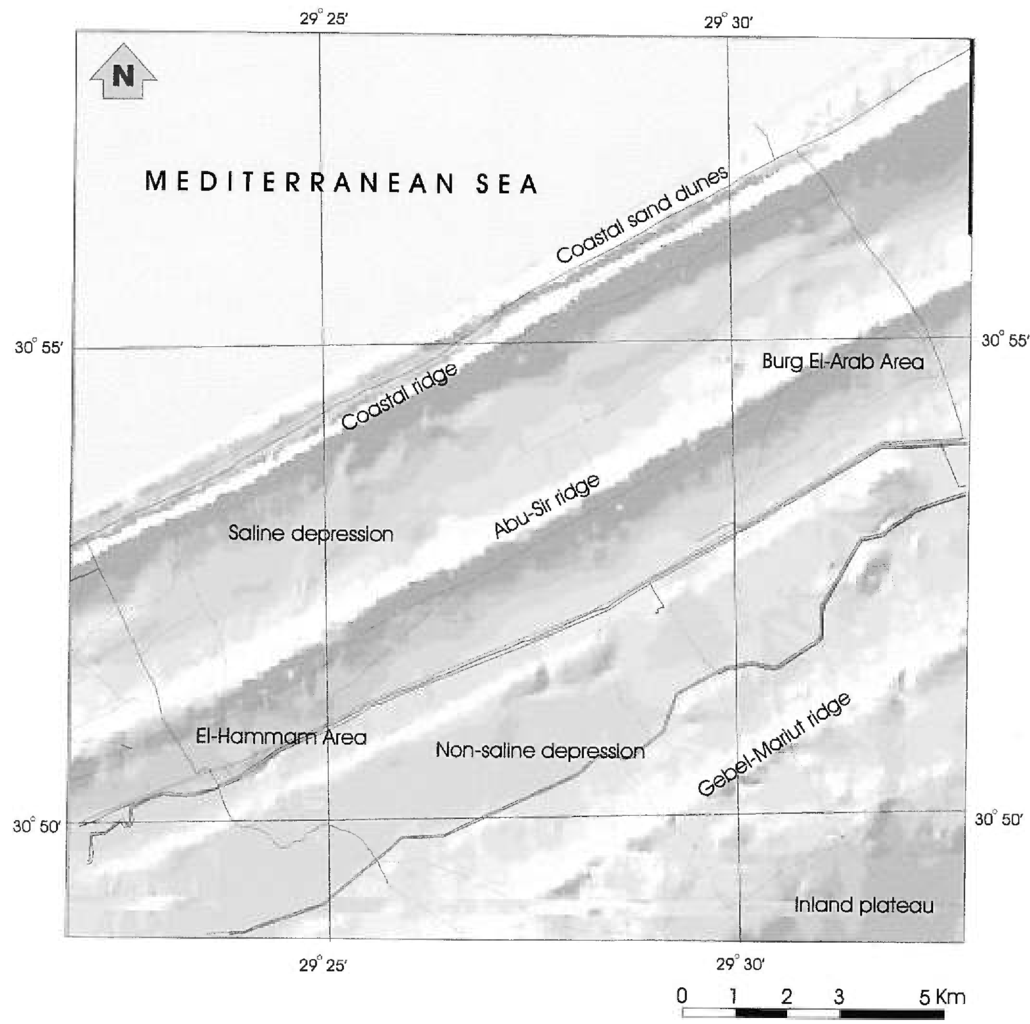


Figure 3.1: Hill-shaded map of the study area in the northwestern coastal region of Egypt.

occupied by Mallahat Mariut depression. It has a width varying between 2-5 km with the surface mostly below sea level, and is filled mainly with brackish water and saline calcareous deposits of weathered and downwash material (Salem, 1989).

In the western province, the coastal plain is narrow or missing. The southern tableland attains a maximum elevation of about 200 m above sea level at Salloum, and slopes gently northwards. Eastward, it descends gradually until it loses its line of demarcation with the coastal plain (Ayyad,1978).

3.2.2.Geology and geomorphology

According to studies on the geology and the geomorphology of the northwestern Mediterranean coastal region of Egypt, the study area is covered by sedimentary formations that range in age from Pleistocene to Holocene[1]. The Holocene formation is formed of: (a) beach sediments, composed of loose calcareous oolitic sands with few quartz grains and shell fragments; (b) sand dunes accumulations, composed of snow white, coarse calcareous oolitic sand; (c) alluvial deposits, composed of fine sandy loam intermixed with gravel, and derived mainly from the older Pliocene rocks; and (d) lagoonal deposits, present in the depressions between ridges and are composed of gypsum intermixed with sand and alluvium.

Pleistocene formation is formed of white and pink limestone located mainly on the ridges, the piedmont, and the tableland (Ayyad, 1982). The rocks in the study area strike in a general east-west direction and dip gently to the north, except where they have been disturbed by structural activity (FAO, 1970). This shows the probability of variation of the engineering properties of the different bedrocks of the study area:

- Generally, the coastal plain geological formations are looser than those of the piedmont and the tableland. The cost of excavations and foundations in similar areas should be carefully considered. Meanwhile, the design of foundations on the ridges of the study area is subjected to the following precautions:

  (a) Variation of bearing capacity with depth;

  (b) Types and amount of salts dissolved in underground water; and,

[1] Both Pleistocene and Holocene are recent geological epochs that make up the Quaternary period. The most recent epoch, the Holocene, began approximaately 10 000 years ago and still continues. Pleistocene goes back to 10^5 years ago (The Oxford English Dictionary, 1989).

(c) Limestone formation is false bedded, hence attention should be paid to mechanical anisotropy in relation to surface discontinuities,

- In the case of any development in the longitudinal depressions between ridges, in addition to the above precautions, attention should be paid to the presence of gypsum layers alternating with limestone beds.

- The presence of a hard recrystallized surface layer on top of Abu-Sir ridge should not be taken as a measure of the strength of underlying formations, which could be significantly variable (PUD, 1975).

- It is also important to mention that the high permeability of the geological formations especially in the coastal plain and some locations of the tableland provides essential media of ground water recharge in the study area. Future development should not impede this cycle.

3.2.3.Soils

The soils of the Northwestern coastal zone of Egypt are derived from two main sources (Kamal, 1988; Ghabbour, 1983):

1. The Mariut tableland (inland plateau) composed essentially of limestone alternating with strata of limestone and shale.

2. Beach deposits composed of calcareous oolitic grains. Land capabilities of these soils fall into 4 classes:

    a. Soils of cultivated depressions in the coastal plain and deep alluvial fans, deep enough to support olive and fruit orchards.

    b. Limited deep soils suitable for shallow rooting crops (barley) and fig orchards.

c. Coarse-textured soils with rock outcrops and the inland sand dunes and sand sheets unsuitable for agriculture except at some favored spots, and more suitable for grazing.

d. Extremely saline, shallow and/or rocky terrain, suitable for low quality grazing.

3.2.4.Climate

The UNDP/FAO report (1971) classifies the climate prevailing along the North Western coast of Egypt as "arid Mediterranean with mild winters". The bioclimatic map of the Mediterranean zone prepared by the UNESCO/FAO (1963) locates the area within the sub-desertic warm climatic zone. The principal factors which determine the climate along this zone as reported by FAO (1970) are as follows:

1. the general circulation of the atmosphere locates the western coast of Egypt in a zone of clear sky, no rain, high radiation and relatively weak wind during the summer months (May to September);

2. proximity of the Mediterranean sea, which has direct effect on air temperature and humidity, and consequently on evaporation and condensation, but does not increase the amount of rainfall; and,

3. the orientation of the coast with regard to the prevailing wind probably provides the explanation for differences in the distribution of rainfall along the coast. The parts of the coast directly exposed to the Northwest winds, as the region from Alexandria to Burg El-Arab receive more rain than those facing the Northeast (Fuka and Salloum) (Ghabbour, 1983; Kamal,1988).

a. Rainfall

Rainfall occurs mainly from November to March in the Northwestern coast of Egypt, all other months are almost completely dry

(Ayyad, 1978), in the form of showers often heavy and thundery. This character, and the small amounts make the deviations from the given averages very large. For example, Salloum had once 121 mm in one day, while having only 40 mm in a whole year, and in another year it had 324 mm (Ghabbour, 1983). 60% or more of the rainfall occurs during winter (November to February) and the summer is virtually dry (Kamal,1988). The annual rainfall varies from one location to the other along the coast. It sharply decreases from about 150 mm near the coast to 80 mm at a distance of 160 km inland, and to 20 mm at a distance of 260 km inland (Kamal,1988). The sequence of water balance is divided into two periods:

1. the period from November to March when precipitation exceeds water need as expressed by evapotranspiration but with no moisture surplus, since the excess is used to recharge the dry soil; and,

2. drying season which extends from April to October when the water need greatly exceeds precipitation, and the actual evapotranspiration falls much below the potential, resulting in severe moisture deficiency.

b. Dewfall

Dew in arid and semi-arid regions is a valuable source of moisture to plants. Kamal (1988) referred to Kassas (1955) in stating that it has been repeatedly observed that some perennials, especially on sand dunes, produce ephemeral rootlets during the dry season, which are believed to absorb dew as it moistens the surface layers of the soil. In fact, climatic conditions in the Mediterranean ecosystems of Egypt are in some seasons favorable for water vapor condensation, such as considerable temperature gradients between different soil strata and overlying air, higher relative humidity, and still wind, particularly during summer and autumn (Ayyad, 1978).

c. *Air Temperature*

The mean annual air temperature in the region differs within a narrow range from one station to the other (Kamal, 1988). The monthly mean air temperature decreases from the west at Sallum (20.5°C) to the east up to Dabaa (19.3°C), and then increases again towards Alexandria (20.2°C). The mean maximum air temperature varies from 16.7°C in January at Burg El-Arab to 31.0°C in August at Sallum, and the mean minimum from 6.4°C in January at Burg El-Arab to 23.5°C in August at Dekheila.

d. *Relative Humidity*

The monthly mean relative humidity is usually higher in summer than in winter (Ayyad, 1978; Kamal, 1988). It ranges between 51% in November at Dekheila to 75% in July at Sidi Barrani. The variation in this climatic element between different stations is small (Kamal, 1988). Evapotranspiration is reduced by not too hot summers and by the rather high relative humidity of the air, especially in July and August when it is most needed. The maritime effect helps Mediterranean plants to extend to depths of 70-80 km inland. All these favorable conditions are unfortunately offset by the scarcity of rainfall that places the region at the limit of the Saharan climate (Ghabbour, 1983).

e. *Wind*

Wind in the region is generally light, but violent dust storms and sand pillars are not rare. The direction of prevailing winds is from the Northwest. However, the area is subjected during spring months to the Khamasein hot storms which blow from the Southeast. At Mersa Matruh and Sidi Barrani, wind blows strongly during the winter and the early spring with an average velocity of about 20-30 km/hr. The wind speed at Alexandria, Dabaa and Sallum is 25% lower than in Mersa Matruh and Sidi Barrani (Kamal, 1988). Ghabbour (1983) added that the wind speed decreases in May and June, but July is windy. Many calm days are recorded in August and September when average speed drops from 18 to 13 km/hr. Wind velocities of 60-80 km/hr may occur twice a year, 80-100 km/hr twice a year, and more than 100 km/hr twice in a decade (Ghabbour, 1983).

3.2.5.Natural vegetation

The natural vegetation of the region includes more than 1000 species of flowering plants, which form approximately 50% of the Egyptian flora (Ayyad and Le Floc`h, 1983; Ayyad, 1978). These species are both annuals and perennials. The annuals are active only during the rainy season. Their appearance and abundance change from one year to the other depending on the amount and frequency of rain. The perennials, on the other hand, form the, more or less, permanent framework of the vegetation, and do not suffer such drastic temporal changes in presence or abundance. This framework of perennials varies spatially due to changes in habitat conditions.

Ayyad (1978), and Ayyad and Ghabbour (1986), (as quoted by Salem, 1989), considered the factors that control the distribution of plant communities in the Northwestern coast of Egypt as: (1) the topographic location; (2) the origin and nature of parent material; (3) the intensity of human activities; and, (4) depth of water table and soil salinity. Many authors have provided detailed descriptions about the vegetation communities and species composition and distribution in the northwestern coastal region of Egypt (e.g. Ayyad, 1973; Ayyad, 1976; Ayyad, 1978; Ayyad, 1982; Ayyad and Ammar, 1974; Ayyad and El-Ghareeb, 1982; Ayyad and Fakhry, 1997; Ayyad and Ghabbour, 1986; Ayyad and Le Floc'h, 1983; Kamal, 1982; Kamal, 1989; Kassas, 1955; Kassas, 1970; Salem; 1989).

3.2.6.Water resources

The water resources of the northwestern coastal region are mainly rain water, ground water and irrigation water. Desalinized sea water may become a major source in the not too distant future (Ghabbour, 1983). Rain water is either lost into the sea, by evaporation, or sinks into deeper soil layers (percolation). Water resources of surface runoff, and the runoff wadis are both products of rainfall and depend on its annual distribution and intensity. Runoff water is utilized in different forms. In depressions, the topographic situation favors the accumulation of runoff of wadis or surface runoff from elevations. Another form is achieved by constructing: (1) dikes to prevent the flow of runoff of wadis to the sea; (2) dikes in the spreading zone, diverting the runoff of wadis; (3) transversal earth barrages to facilitate sedimentation and create terraces which in general receive abundant runoff from wadis; and, (4) small dikes parallel to the contour lines to attain the surface runoff (Kamal,1988).

Water also brings life to vegetation, crops, livestock, and people, and fills wells and cisterns (Ghabbour,1983). More than 3000 cisterns dating back to the Roman period exist in the coastal region. Several hundreds of additional new cisterns have also been built during the last few decades. They provide the main drinking supply for the people and animals inland (Kamal, 1988).

Most of the surface and ground water is of good quality for agriculture. The irrigation water is confined to the eastern part (Burg El-Arab and El-Hammam), and is brought by Bahig Canal, and more water is brought by the much larger Naser Canal (27-37 km south of the seashore) (Kamal, 1988). Ghabbour (1983) recommended that efforts must be directed to utilize dew as one of the complementary water resources in the region.

3.3.Human population and land use types

Estimations of population of the North Western coastal zone vary according to source, inclusion and exclusion of certain areas (Siwa Oasis, Amerya) or certain ethnic groups (migrant employees and workers from the Nile Basin). The oldest estimate is 49,000 for 1927 and the latest is 130,000-159,000 for 1979. It may reach 233,000 in the year 2000, at a growth rate of 3.7% per year. In 1978, there were 23,730 households in the zone, meaning 5-4 persons per household. There were 43,000 children at less than 12 years of age, representing 24% of the population. People above 65 years of age represented 2.85% of the population (Ghabbour, 1983).

It is estimated that the age class 0-14 years contributes 25% of the labor force. The participation of the age class 15-59 years is 100%, and of the age class older than 60 years 50%. No difference in participation is assumed for men and women. The total available work force in the whole coastal zone, converted to « standard », adult laborers, is 49,400 persons.

The main land use types in the northwestern coastal region of Egypt are: (1) rain-fed farming and cropping, (2) grazing, (3) mining, and (4) tourism and recreation. Irrigated agriculture has been introduced to the area between Burg El-Arab and El-Hammam (the study area) since the early seventies, and is planned to extend more west in the future. Traditional water management strategies are: (1) wells, (2) cisterns, and (3) Karms[2]. Wells derive their water from a thin layer of fresh water over salty water. The introduction of wind-mills introduces also the danger of exhausting the fresh water layer or mixing it with the salty water underneath. The ground water resources must be carefully utilized. There is also danger of soil salinization when using saline water for irrigation. Wells and cisterns are less utilized at more than 10 km from the coast. Further expansion of permanent human habitation to the south must depend on exogenous water (Nile water, or desalinized seawater).

3.3.1.Agriculture

Agricultural activities in the North Western coastal zone of Egypt could be divided into two types: irrigated and rain fed.

a. Irrigated Agriculture

Irrigated agriculture is confined to the area between Burg El-Arab and El-Hammam. Irrigation water is brought by Bahig Canal. This irrigation water is very costly in terms of investments and loss of resources (higher saline ground water level, loss of fertile cultivated depressions) and is not managed efficiently because of conflicts with navigation requirements in the Nubareia Canal, from which this water is derived (Ghabbour, 1983).

[2] Karms are ancient runoff rain water collecting agricultural fields (refer to section 3.4 later in this chapter for a detailed description of the Karms system)

The societies have witnessed the implementation of governmental rural management policy in the Burg El-Arab area, and with it there were great changes in the agricultural practices and sociological structure, specifically by the mobilization of labor force. Crops which are successfully cultivated in Burg El-Arab area are barley, clover, beans, almond, olive, guava, peaches, apple and citrus as winter crops, and maize, water melon, tomatoes, cucumber, cabbage, eggplant, and green pepper as summer crops.

b. Rain-fed agriculture

The principal crop cultivated by rain-fed farming is barley. Trees of olives and figs are also grown without irrigation, except in the dry seasons of low rainfall (Salem, 1989). In good years when yields are sufficient to produce a surplus of grain, the surplus is stored under mounds of earth. Conversely, in dry years, when the rain is not sufficient to produce a crop, animals are allowed to graze on the shoots that emerge. Rain-fed cultivation on the southern plateau, especially in Burg El-Arab are associated with Karms. These are ancient runoff rain water collecting agricultural fields. Bedouin in Burg El-Arab area say that Karms were made by the Romans specially for cultivating fruit trees. They are now used by Bedouin for barley cultivation. These Karms, which consist of substantial earth works are still prepared and cultivated each year (Salem, 1989; Ghabbour, 1983). Salem (1989) added that the cultivation at the Karm sites is not restricted to the inner field but substantial areas are also cultivated surrounding the Karms. The Karms extend 30 km inland and mark the limits of cultivation. There must be 5 acres of highland watershed capturing the run-on water (Ayyad, 1978). More description of the Karms is presented in section 3.4 later in this chapter.

In general, until about two decades ago, the main crop was barley which was not a dependable venture, and was helped by olive and fig cultivation, as well as livestock herding. With recent changes in better communication, affluence, the coming of irrigation water, etc., traditional crops are being replaced in the eastern part by irrigated crops, e.g. maize, berseem (Egyptian clover), alfalfa, or fruit trees such as pear, south of lake Mariut. Between Lake Mariut and the seashore, fig trees are uprooted to make way for resort and touristic villages.

This change in crop pattern in the eastern part is offset by intensification of olive and fig cultivation further west, and mechanization of barley cultivation with expansion of its area into grazing lands. Barley production amounts to 10,000-30,000 tons a year from 20,000-50,000 ha, and is not yet fully mechanized due to the risk of lack of rainfall (Ghabbour, 1983). Barley is no longer a staple food for humans and is used mainly (clums and grains) for forage.

Figs are successful and profitable on the first and second ridges, and in the depression between the third and the fourth ridges where there is a permanent wet layer at a depth of 2 meters. Olives do well also in the aforementioned depression. Bedouin have learned the advantages of fig and olive cultivation (and other trees such as almonds, vines, date palms, pomegranates and pistachio), especially that the government recognized the Bedouins ownership of the land only if it is under orchards. This is a welcome attitude, since barley cultivation represents replacement of the natural climax vegetation protecting the soil and providing it with soil-building organic matter, by an artificial plant growth with comparable structure and ecological relationships and effects (Ayyad, 1978).

3.3.2.Pastoral activities

The main land use in terms of area, however, is grazing. It is often mentioned that intensive grazing and the nomadic life have played a great role in the destruction of vegetation cover in semi-arid region of the world, But this claim is valid only because human population and livestock numbers have swelled beyond the carrying capacity of the life-support systems in grazing lands, by interventions of colonial and/or westernized independent governments (Ayyad, 1978). As quoted by Ayyad

(1978), these interventions are summarized by Picardi (1976) as: (1) elimination of tribal warfare (in west Africa, and elsewhere: peaceful sedentarization); (2) digging of permanent wells (by modern technology); and, (3) vaccination programs to eliminate livestock diseases, and (4) public health, sanitation and vaccination to programs against human diseases. The effect of these measures was to increase the number of pastoralists, to increase the total number of stock, and to increase the duration of transhumance.

In order to give just a quick idea of the extent of damage done to the vegetation at present by wood cutting, Ayyad (1978) assumed that every one of the 20,000 families of Bedouin living in the region at present, burns at the rate of just one shrub per day. This makes 7.3 million shrubs per year. Since the average density of shrubs suitable as fire-wood is about 65 per hectare, the shrubs are removed from an area of more than 110,000 ha annually from the northwestern coastal desert of Egypt.

Land degradation is mainly represented by the destruction of plant cover. The plant cover acts as obstacles to runoff and provide physical resistance to wind. If it is reduced by wood-cutting, overgrazing, ploughing, or by cutting and leveling the landscape, the surface layer of soil regresses under the effect of water erosion or wind deflation. With sedentarization, the harvesting of fuel wood becomes more intensive and overgrazing represents a serious stress on range lands. It is also accompanied with the application of new technologies in cultivation, and establishment of quarries for the construction of new villages and summer resorts.

3.3.3.Mining and tourism

Mining as land use is limited to: gypsum, limestone, and loamy topsoil. This last resource is dangerously being excavated extensively between the littoral and second ridge near Alexandria, and thus turning wide areas of useful grazing land into salt marshes. These marshes, besides being a loss of valuable grazing resources for their proximity to Alexandria, pose serious health hazards to the local population and reduce the amenity value of the coastal tourist and recreation villages nearby (Ayyad, 1978).

The construction of summer resorts along the coast with its continued quarrying and leveling of the landscape are extremely obvious. Quarrying practices keep on cutting of the ridges for brick-making. The natural landscape is therefore obliterated beyond recognition. The process destroys natural vegetation, and creates its own environment in contrast of what the heritage implies. Multistory buildings are now obscuring the view to the Mediterranean, and therefor destroying aesthetic values and visual experience of travelers along the coast.

3.4.Historical overview

By 560 BC the Greeks established a colony in Cyrenaica[3] and were tributary to the 26th Egyptian dynasty. After a brief Persian occupation, the Greeks came back and established a chain of colonies in Cyrenaica and along the northwestern Egyptian coast (refer to figure 1.1 in Chapter I). These colonies paid allegiance to Alexander the Great when he marched to Siwa oasis in the west, a journey which was beneficial to the coastal strip and its inhabitants, who became prosperous and were granted autonomy by the Ptolemaic dynasty. Rome occupied Cyrenaica in the first century BC and Egypt in 30 BC (Ibrahim *et al,* 1989). Under meticulous Roman rule, the productivity of the entire north African coast, from Alexandria to Numidia (present-day Algeria) was maintained at such high levels that fertility of the Nile Delta and valley was obscured in comparison. The Delta itself once was a group of ponds where hunting and fishing formed the main human activities in 3000 and 2000 BC and was subject to dryness till it was exploited as fertile agricultural fields (Bonneau, 1987). An elaborate integrated development plan, comprising introduction of new crops, new agricultural techniques, a network of roads and observation posts, cisterns and other soil conservation and water harvesting projects, plus ingenious administrative and land-tenure regulations, was put into action and preserved for several centuries. The Romans improved on the already Greek working system. Mareotis also produced some of the best wine of the Roman empire, which was already famous at the time of Egypt's annexation by Octavius Augustus, showing that it was produced by Ptolemaic Greeks. Wine presses recently discovered in the region which was dating from the

[3] Cyrenaica is the area of north east of Libya

second century AD is exactly similar to present-day wine presses in Burgundy, going back to Mediaeval times (Figure 3.2) (Ghabbour, 1989).

Figure 3.2: An example of a wine press lately discovered in the Northwestern coastal zone of Egypt. Which dates from the second century AD

There has long been controversy whether the prosperity of Mareotis[4] could be attributed to better rainfall. Several pieces of evidence indicate that the climate of Mareotis during the Roman period was not much more humid than it is now. A calendar of ancient Alexandria shows that it had the same number of rainy days per year as it has now. It appears that the asset Romans used very efficiently a cheap forced labor which enabled them to build extensive and efficient water storage and conservation works which allowed the area to produce enough barley, wheat, and grapes to feed and please the metropolis.

Utilization of water resources by the Graeco-Romans is the key to their prosperity, and its collapse the key to its decline (Ibrahim *et al,* 1989; Ismail *et al,* 1976). The location of farms managed by a resident population far from the Canopic branch of the Nile, or the then freshwater lake Mariut, indicates that effective methods of dry land farming were used. It depended on ingenious methods of water distribution that took full advantage of local topography and of artificially build rectangular ridges known today as Karms (singular Karm). The local topography is characterized till now by these karms (Figure 3.3), they provide runoff water which

[4] The ancient name of the northwestern coastal zone of Egypt

brings silt to the depressions and create a cultivable habitat. They are scattered over the country in great profusion (Figure 3.4). The karms are thought to be of Roman origin and consist of banks of earth up to 5 meters high (FAO 1970). They are formed in rectangular or horseshoe shapes and have both central and external fields. The soils on which the karms occur are clay loam which form impervious crusts during rain storms. Individual karms, as seen in aerial photographs, are visible on the inland plateau as a bright area of bare soil (of varying size) with a central spot of cultivation, and frequently with cultivation surrounding the karm on the outer slope (Richards, 1989).

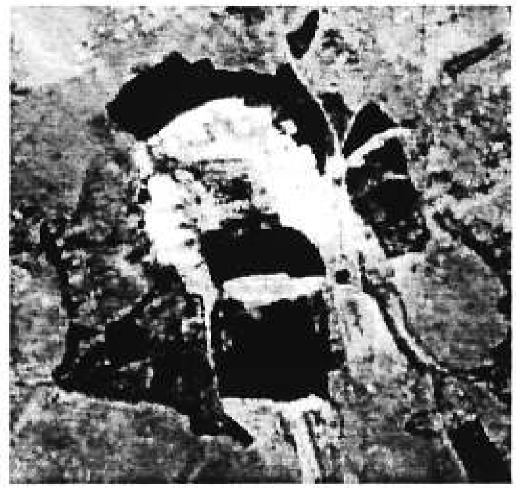


Figure 3.3: Aerial photograph of a Karm located south of Burg El-Arab area (1955). Agricultural fields are located inside and around the man-made hills.

The Ptolemaic and Roman periods were marked with peace and prosperity, although a few brief but violent wars broke out, a number of plagues ravaged the coast, and four earthquakes shook it. Albeit these shocks, the coast could recover and continue its prosperous normal activities. Later on, the Arab came in 642 A.D., and the coast remained a grain and wine producing area for two and half centuries more. By the end of the ninth century, attacks by Berbers and marauding Arab tribes (Beni Hellal and Beni Suleim), chased from Egypt, brought havoc among the resident population. As a result of neglect, the Canopic Nile was silted and finally disappeared in the 12th century.

Figure 3.4: An example of a Karm located south of Burg El-Arab area. The man-made hills act as water-harvesting system in rainy seasons.

Under the Mamelukes, resident Arabs found the land ideally suited for grazing and some barley cultivation, as they still do now where they have to be self-sufficient. The importance of the region as a productive element was severely reduced. On the other hand, more attention was given to the Nile Delta during the 19th century, which attracted Bedouin (the desert inhabitants) to settle west and east the Delta. This immigration reduced the number of western desert inhabitants till the beginning of the 20th century, until the oil was discovered in the Libyan desert. This attracted the Bedouin population as it raised the employment opportunities and family income.

The world war two, on the other hand, has paid the attention of the British colonization forces to the western gate of Egypt. The western desert has witnessed the great battle of El-Alamein, in which the British forces halted the sprawl of the Italian and the German forces to the Egyptian territories.

After the Egyptian revolution of 1952, the nation had put great attention to the development of the Egyptian deserts in general, and to the western desert in specific. This was occurring in order to redistribute the population on the Egyptian territory. In the first attempt to reclaim desert land, the Mudireyet El-Tahrir project was started in the second half of the 20th century at the western side of the Delta. It can be said that in this period, the government promoted the settlement of the Bedouin by providing them the reclaimed land and promoting any agricultural activities in these areas. The aim of the government then was to create a settled Bedouin society, hence, no attention was given to the western desert as a future solution for urban development.

Recently, the northwestern desert has been looked at for the habitation of more than 4 million, with the economic development varying from agriculture (rain-fed, or irrigated), pasturing, fishing, tourism, oil exploration, and petrochemical industries, aiming to increase the total national and regional income with the increase of the economic base of the nation, and to redistribute the large population concentrations existing in the metropolitan areas by creating new social and economic attractions in the region.

3.5.Anthropological overview

After the Muslim Arabs came to Egypt (commanded by Amr Ibn El-Aass in 640 A.D., and subsequently by Okba Ibn Nafe and others), some of the Arabian tribes settled in the western desert due to the existence of cisterns and fertile pasture lands. They formed nomadic groups that were always traveling in the western desert. No national limits existed, but therefore, ethically tribal defined boundaries were characterizing their movements. At the time, the value of the land was almost negligible, the real value prevailed in the vegetation cover or the water resources that existed on its surface. Therefore, conflicts and disputes were rare events in the region. Again, by conventional means, the diverse tribes agreed to subdivide the land between them.

The dominant tribe in the northwestern coastal area of Egypt is the Awlad Ali Saadi tribe. They claim to have obtained rights to land in the Western Desert by conquest in the last century, and that the tribe living there before them was transferred by the Egyptian government to the Eastern Desert, though some remained near

Alexandria. The majority of the Saadi still live in Cyrenaica (The Northeast of Libya) from where the Egyptian Saadi came. In Cyrenaica, there are two major ecological zones, the red lands or coastal plateau (terra rossa), and the white lands or semi-desert. Both areas are occupied by Saadi tribesmen, but those in the more marginal white lands are camel and sheep pastoralists and barley cultivators. The term «red» and «white», used by the local inhabitants to characterize the distinct ecological zones (and land use patterns) in Cyrenaica, are also used in Egypt Western Desert to distinguish two branches of Awlad Ali (Saadi): Awlad Ali "El-Ahmar" (red) and Awlad Ali "El-Abiad" (white) (Ghabbour, 1983).

There are other tribesmen in the area who do not belong to Awlad Ali, but belong to a number of different tribes. They are collectively known as "Mrabtin". They are described as fragmented and weak and protected by the Saadis, but who have some aura of religious respect among their protectors. They are attached as individuals or in small groups to local groups of Saadis, as clients, or they live with economic independence in their tribal groupings between or beyond the areas occupied by the Saadi.

The more favorable land of the coastal strip is occupied for the most part by Saadis, while the less productive lands of the interior are inhabited by Mrabtin, the traditional client tribes who herd their own animals as well as those of their Saadi protectors during the winter season when the coastal zone is planted in barley, and then provide the labor for the barley harvest later in the season, bringing the herds with them to graze the stubble and to congregate near wells for summer (Ghabbour, 1983).

The intimate relationships are utilized in managing the economy in an unofficial manner throughout the whole region. Each tribe is organized into a number of "ailas" (families). While the aila is usually associated with a certain geographic location, which is considered a homeland (watan), it rarely, if ever, utilizes this land as a corporate unit. Instead the land is divided among the various "biut" (homes) constituting the aila. The land of the bait is sometimes divided into several "hosh" (fields) in very different places. When the land of a bait or a hosh is undivided, each of its members can, at least theoretically, cultivate or graze any part of it. Thus it becomes a communal possession or corporate unit. This is, however, usually not the case in the land that is cultivated as orchards. While individuals know the land belonging to their bait or hosh, their individual right is not always associated with a specific patch within the bait area. Sometimes an individual claims or is given the right to a specific patch and the right to sell it. This is usually the case for land cultivated as orchards and sometimes for barley. Usage rights are treated the same way as ownership.

Boundaries of cultivated land are protected. Grazing lands are not enforced particularly within a specific aila. Members of other tribal segments are allowed to graze their flocks wherever grazing lands are available, but they are not allowed to use the wells and cisterns. While animals are always in individual property, water for the flocks belongs to the bait owning the cistern. While the use of the water for animals and agriculture can be sold to outsiders, drinking water for humans is given to anyone in need of it.

3.6.Transformation in the population structure

The changes introduced by the government, threw the life of Bedouin into a process of sedentrization. This is characterized by three major phases:

3.6.1.The nomadic phase

This describes the way of social and economic life of some tribes which are still moving from one place to the other for the search of good pasture lands. Among those, few are practicing seasonal rain-fed agriculture. They are still governed by the conventional ways and customs which is totally independent from the governmental laws. This characterizes the Bedouin lifestyle and their tendency to the "self liberty" according to their tight relations to their original tribes that control them politically and administratively. They live deep within the desert some kilometers from the main road between Alexandria city and El-Salloum. They are pastoral and engaged in livestock herding only and are tent dwellers who count their population and describe their settlements by the number of tents. The herding units are considered social units which are almost self-sufficient economically.

3.6.2.The semi-nomadic phase

This refers to the semi-settled aspect of some tribes which transformed their nomadic activities with a seasonal movement between their settlement areas and the traditional pasture lands. In this phase, the family settle in their sedentary homes while they send a member or any hired individuals to the pasture land to take care of their animals. They are dispersed inland from the railway line and live in patterns of isolated, or individual dwellings where extended families settle near their land-holdings. Some of the recent settlers live in association in compact camps in their tribal areas. They prefer to live in scattered permanent houses but may own a tent for summer and special occasions. These rural settlers are still engaged in livestock and farming.

3.6.3.The sedentary phase

This describes the permanent settlement of the families and individuals in certain places (mainly major urban centers). This is mainly accompanied with instant changes in all socioeconomic aspects, and transforms the nomadic culture from pasturing activities and seasonal rain-fed agriculture to a settled life based on agricultural and industrial activities. The settled populations are concentrated in the urban areas. Some additional economic activities have appeared such as construction, carpentry, plumbing, civil services, tourism, and trading.

It is to be stressed that, although there is no information indicating the changes in the relative numbers of the populations of these three main categories of lifestyles throughout the history of the study area, it may be safely stated that the population structure has changed from an overwhelming majority of nomadic population (>75%) to an overwhelming majority of sedentary population (>75%). This trend of change in lifestyle of the population in the study area is confirmed by the data recorded by Ayyad and LeFloc'h (1983) indicated in the following table:

Year	Houses		Tents	
	Number	Density /km2	Number	Density /km2
1954	4	<0.1	55	1
1962	12	<1	30	<1
1979	50	1	2	0.04

These data (number of houses reflecting sedentary lifestyle, versus number of tents reflecting nomadic lifestyle) indicated the changes in El-Omayed area (30 km west of the sites of the present study) from 1954 to 1979). The change is obviously from an overwhelming nomadic lifestyle (density of tents ten times that of houses), to an overwhelming sedentary lifestyle (density of houses fifty times that of tents). But it has to be stressed that one cannot put sharp limits between the three lifestyles, since a notable percentage (>25%) of the semi-nomadic and sedentary populations still practice a nomadic way of land-use, especially concerning herding the grazing animals during the rainy season.

Furthermore, in the process of developing the northwestern desert, many employment opportunities were created, which affected the population composition of the area. Beside the original inhabitants, the Bedouins, other immigrant population are occupying the area. These are mainly coming from the Nile Delta, Libya, and El-Arish (north of Sinai). The Nile Delta immigrant population is mainly attracted by the development projects and the government employs them. They also work in the utility sectors, commerce, and hand works. The Libyan, immigrants, on the other hand, came to the area in the twenties and after the world war two, they are mainly concentrated in El-Hammam area. They worked in the commerce of food and clothes. Lately, their numbers decreased dramatically due to oil exploitation in Libya. Small groups of about 400 peoples are still living in the area. Finally, the immigrants coming from El-Arish area, are less in numbers than those coming either from the Nile Delta or from Libya. They arrived in the area during the 1967 war to work in the national projects of land reclamation of Mariut region. Many of them are settled in the area till present. Conceivably land use must have changed accordingly: urban sprawl, destruction of limestone ridge for making building bricks, disturbance of the coastal dunes by establishing summer resorts, expansion of rain-fed and irrigated agriculture to more fragile sites, and exerting greater stress of grazing and wood-cutting on marginal lands.

After this extensive presentation of the selected study area, it becomes clear that it has witnessed remarkable changes in the past centuries and decades. This calls for an evaluative method to analyze the evolution of its components, and to assess the influence of different actors and forces in shaping its components throughout time.

CHAPTER IV: MATERIALS AND METHODS

4.1. Selection of landscape attributes

The previous chapters make it clear that there are problems of landscape planning and management in the northwestern coastal region of Egypt. This region has witnessed rapid notable changes in its natural and cultural landscape components. These changes calls for an in-depth study that integrates multidisciplinary information and data from different sources in order to understand landscape dynamics, and to evaluate the impact of the interacting factors that have shaped its components during the past decades. With such understanding, planning and management recommendations could be proposed for the sustainable development of natural resources.

The two basic main concepts of landscape ecology discussed in Chapter II, namely multidisciplinarity and holism call for the selection of a variety of ecological, socioeconomic and visual attributes for the analysis of the landscape of the study area. A systems approach integrating these attributes is to be adopted for achieving the objectives indicated in Chapter I. Conceivably, ecological attributes are related to both the physical environment (physiography, geomorphology, soils, and climate) and the biotic environment (mainly vegetation) described in Chapter III, which contribute to the definition of the shape, size and number of landscape patches. Also, the human dimension introduced in Chapter II, and further discussed in Chapter III, calls for the consideration of the socioeconomic attributes (e.g. population distribution and economic activities) which also contribute significantly to the shaping of the landscape of the study area. Besides, the recent development of tourism and holiday-making in the study area indicated in Chapter III, have had notable impacts on its landscape, and calls for consideration of visual attributes (e.g. land-use/land cover diversity and activity).

With this perspective, landscape attributes were selected for landscape analysis in the present study. These attributes were identified on the basis of their relevance to the description of the landscape of the study area, and according to the corresponding data availability. In the present study, two visual attributes were selected for assessment after comprehensive examination of the relevant literature (e.g. Fabos *et al,* 1978; Mooney, 1983; Smardon and Fabos, 1983; Musick and Grover, 1991; Brown, 1994; Crawford, 1994). These are the land use/land cover diversity, and activity (degree of naturalness). In selecting these two attributes care was taken to use remotely sensed data generated from relatively high resolution sensors.

On the other hand, the selection of the ecological attributes should be based mainly on the analysis of the structure and function of different landscape elements. In the present study, three ecological attributes were selected: shape, size and number of land use/land cover patches. These attributes provide useful information for the assessment of landscape patterns and changes in its structures (O'Neil *et al*, 1988; Kienast, 1993). Shape indices of landscape pattern have often been referred to as "fractal dimension", and are presented in literature to describe the complexity of patch shapes in the landscape. The two other indices, number and size of patches, are good indicators of fragmentation processes[1] (O'Neil *et al*, 1988; Kienast, 1993; Hulshoff, 1995). The Change in the fragmentation of landscape patches, in general, describes the evolution of the designated landscape from natural to man-made land use/land cover.

On the other hand, the socioeconomic attributes were selected according to the available relevant descriptions of the study area. The most extensive and accurately documented information is that about two attributes: the population distribution and age structure, and the economic activities of the inhabitants. Information about these two attributes was, therefore, collected at different dates, with the objective of

[1] Fragmentation is the breaking of an object into pieces. Habitat fragmentation is but a phase in a broader sequence of spatial proecsses transforming land by natural or human causes from one type to another (Forman, 1995)

revealing the changes in the social fabric and the dynamics of the economic structure in the study area (Nakagoshi and Ohta, 1992; Ispikoudis *et al*, 1993).

4.2.Methodological approach and Data Availability

A prerequisite for data capturing is an approach that would provide an adequate context within which any attempt to build a conceptual model of GIS should be based. The approach adopted for the present study depends mainly on "map-based geo-information systems". Two main sources of data may be identified: (a) existing published information in the form of historical data of human population, land use, and environmental change in the form of charts, tables and graphs, as well as existing mapped information (e.g. maps of geographic location, topography, vegetation, etc.); and (b) spatial data analysis adopted by this study in the form of field survey data analysis, aerial photograph interpretation, and processing of satellite imagery. Aerial photographs were selected at different points of time, when traditional land use was dominating, and when the modern technology in agriculture and building of settlements and resorts was subsequently applied. Captured data guided by this system of land use/land cover units (after digitizing and scanning the existing maps and aerial photographs) was stored either graphically or non-graphically.

Meanwhile, reconnaissance site visits were made in order to gain spatial recognition of different land uses and to acquire information relevant to the study objectives. Preliminary interpretations of the data generated from selected satellite images, aerial photographs, and maps of the study area were based on information obtained from these reconnaissance visits. It was also important to extract specific data concerning the environmental characteristics of the area under consideration before and during the analysis. General knowledge about different land use types was also acquired during data collection. The reconnaissance visits contributed to the comprehension of environmental characteristics of the landscape, and the existing land use diversity was noted and photographed in order to help in the characterization of the general landscape elements.

Two types of data were needed to conduct the present study. The first type was the socioeconomic data that consisted of the history of the northwestern coastal zone of Egypt, and the corresponding qualitative descriptive documents, the population distribution, and the economic activities of the inhabitants. The second type included the spatial data, which provided information about the land use/land cover of the region at different dates; these were obtained from the Department of Environmental Sciences at the Faculty of Science, University of Alexandria.

4.2.1. The socioeconomic data

The socioeconomic data were obtained mainly from the reports of the Central Unit of Population Census and Statistics of Egypt of 1960, 1976, and 1986. They described and quantified both the economic activities of the inhabitants and the population distribution for Burg El-Arab and El-Hammam. Historical and qualitative descriptive data were obtained from Ismail *et al.* (1976), Ayyad and Le Floc'h (1983), Ghabbour (1983), Wilder (1984), Ibrahim *et al.* (1989), and Ayyad (1995). Information in these references included the evolution of the population structure, the change in the natural resources from the Graeco-Roman period till present, the size and projections of investments, and insights in population growth, and industrial and agricultural development.

4.2.2. The spatial data

It was evident that several spatial data formats had to be used because of the long time period under investigation. Therefore, these data were collected in three formats: topographic maps, aerial photographs, and satellite images.

a. The topographic maps

The 1:50 000 topographic map of 1977 was used mainly for two purposes. First, it was used as a basic map for registering all other remotely sensed data in order to obtain a set that is projected, georeferenced, and with standardized measurement units. Second it contained the contour lines of the region which could be used to calculate the surface slope and to construct a

Digital Elevation Model (DEM) for the region. Therefore, the major features (e.g. major paved and unpaved roads, highways, railway lines...etc.) and topographic contour lines were extracted and digitized using a digitizing tablet (A0 size) and AutoCAD drafting software. Data were then exported to IDRISI, an image processing and Geographic Information Systems (GIS) software in vector format, by which it was possible to adjust the coordinates and the projection through registration to the original map coordinates (geographic projection and decimal-degrees units) following a selected set of Control Points (CPs). The registration procedure uses this set of CPs to refer to the corresponding projected coordinates and thus enables applying the same algorithm on the whole map by means of "rubber sheeting" to their new correct geographic location. The final result of this procedure produced a geographically projected map with decimal-degrees units. It contained information about the major features and the contour lines of the study area (Figure 4.1).

b. The satellite image processing

SPOT XS satellite images of April 10th, 1987 and September 2nd, 1992 (three spectral bands of 20m x 20m spatial resolution), and SPOT Panchromatic of June 23rd, 1987 and May 31st, 1994 (one spectral band of 10m x 10m spatial resolution) for the study region were acquired and processed.

- ***Data registration and coordinates rectification***

All images (SPOT XS of 1987 and 1992, and SPOT panchromatic of 1987 and 1994) and associated bands were registered to fit the topographic base map. This process of georeferencing involved geographical projection of all bands, by selecting a set of CPs in each image that corresponds to their original location in the base features map, and performing resampling (cubic convolution algorithm).

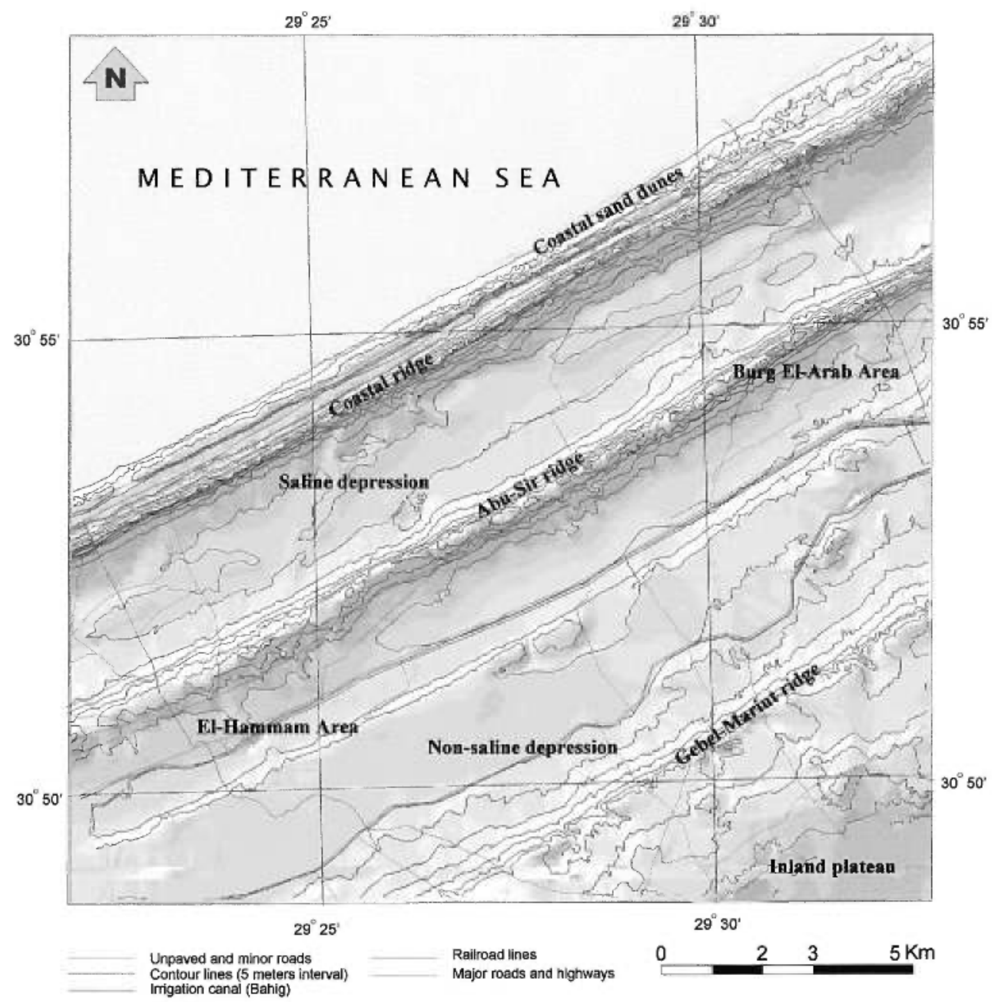


Figure 4.1: Hill-shaded Map of the study area (the northwestern coastal region of Egypt) delineating the contour lines and the major features.

The resulted RMS[2] error was less than a mean of 2 pixels for all images. CPs in this step were selected simultaneously in two windows; the first of which displayed the image to be registered, and the second displayed the reference map that contains the digitized projected major features. This procedure was carried out using ERDAS IMAGINE (version 8.2)[3] running under Windows NT operating system. Finally, four sets of geographically

[2] Root Mean Square
[3] raster image processing software

projected images were produced and were ready for further classification, analysis, and comparison.

- ***Image visual interpretation and features identification***

Images were displayed separately for visual analysis, in order to identify their features, attributes and specifications. Histograms of the selected multi-band images were produced in order to identify the spectral characteristics of the major land cover types (Figure 4.2 (a) and (b)). A quick clustering method was applied to the multispectral image of each date in order to classify and identify clusters of interest and to define the number of classes to be considered in further accurate classifications.

The main problem encountered was clearly presented in the heterogeneity of the spectral and spatial distribution of land cover types in the selected study site, beside the highly reflective nature of the scene background (open land and the sparsely vegetated areas) which had a spectral reflectance that overlapped with other highly reflective elements such as the built environment. Another problem prevailed, which is the spectral similarity between some agricultural field classes and densely vegetated salt-marsh areas.

In order to avoid these problems that can highly affect the classification accuracy of the land cover types of the study area, a masking technique[4] was applied to treat each of the above mentioned features separately, and mask them out from the original scene to remedy their high spectral and spatial heterogeneity. The classification of the rest of the image land cover types, as explained later on, (histogram in Figure 4.3 (a) and (b)) produced more accurate results than those obtained by using the original image without masking. Thereafter, the separated parts of the image (containing the built zones and the salt marsh areas) were classified separately (histograms in Figure 4.4 (a) and (b) and Figure 4.5 (a) and (b)). The three resulting classifications of images were added

[4] This was carried out using approximate on-screen digitization of selected feature areas on the set of SPOT high resolution Panchromatic images (10 x 10 meters).

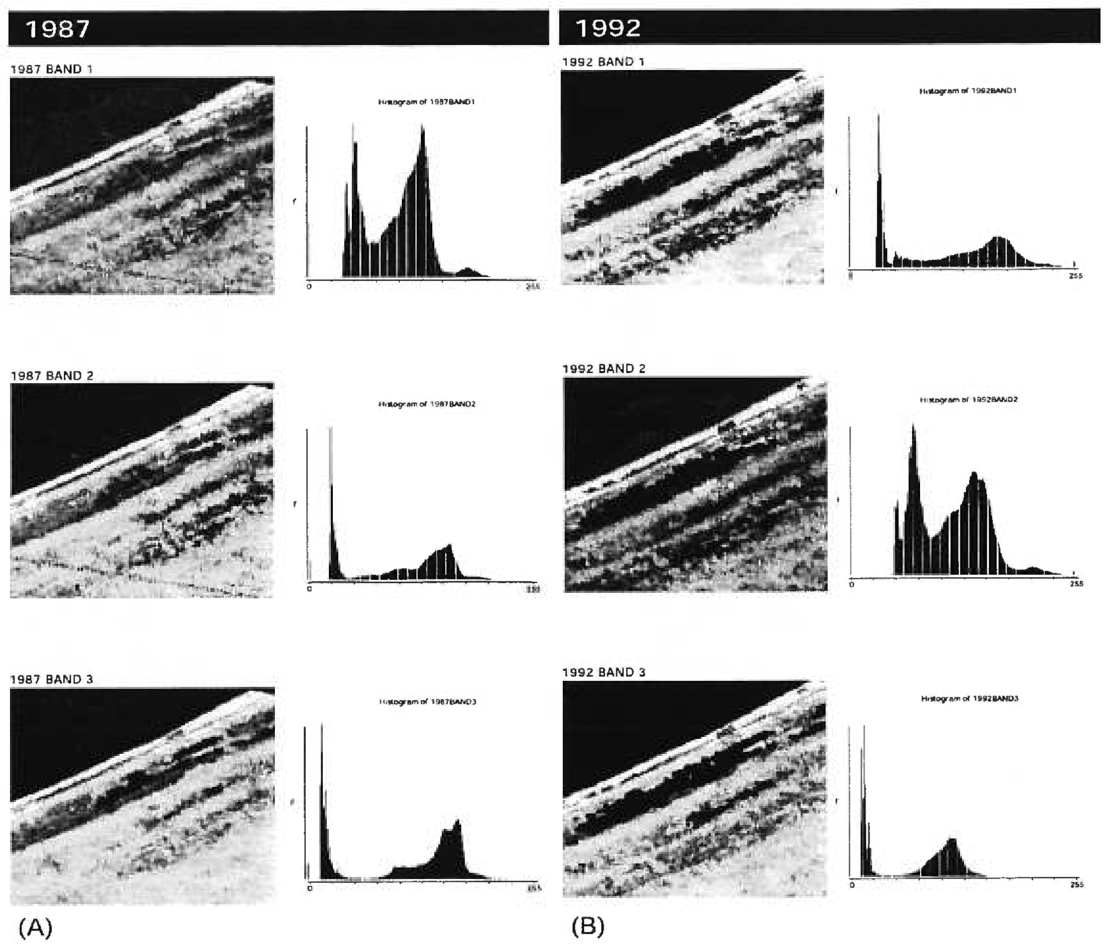


Figure 4.2: The original SPOT XS scenes of (A) 1987 and (B) 1992 and their corresponding histograms.

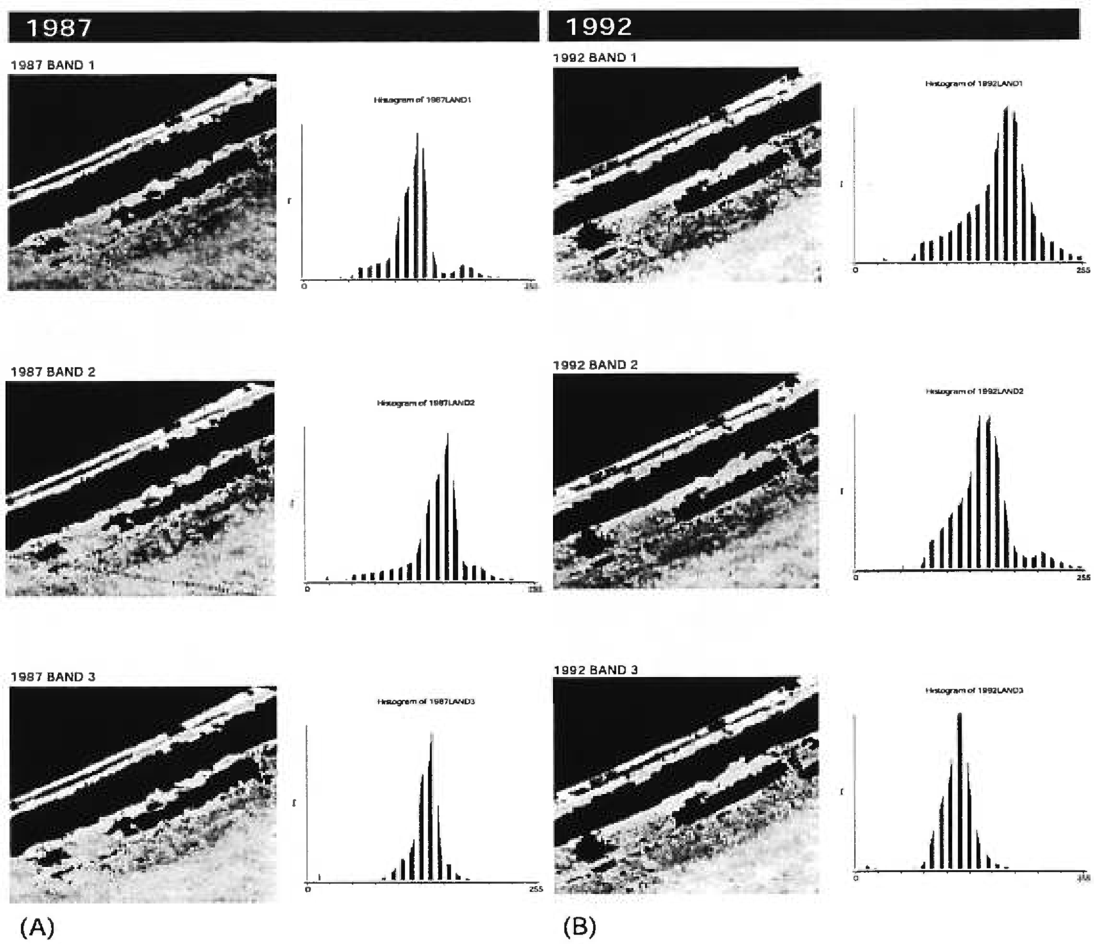


Figure 4.3: The extracted land areas of (A) 1987 and (B) 1992 and their corresponding histograms.

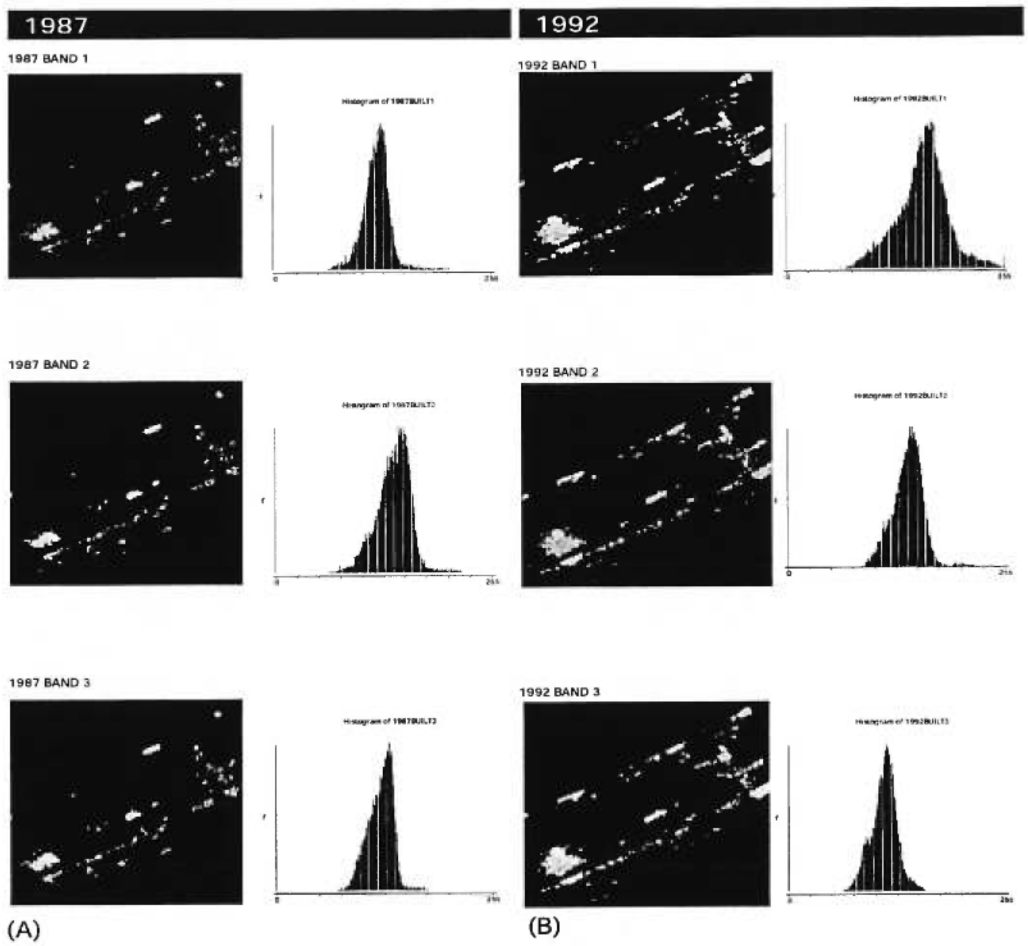


Figure 4.4: The extracted built-up areas for (A) 1987 and (B) 1992 and their corresponding histograms.

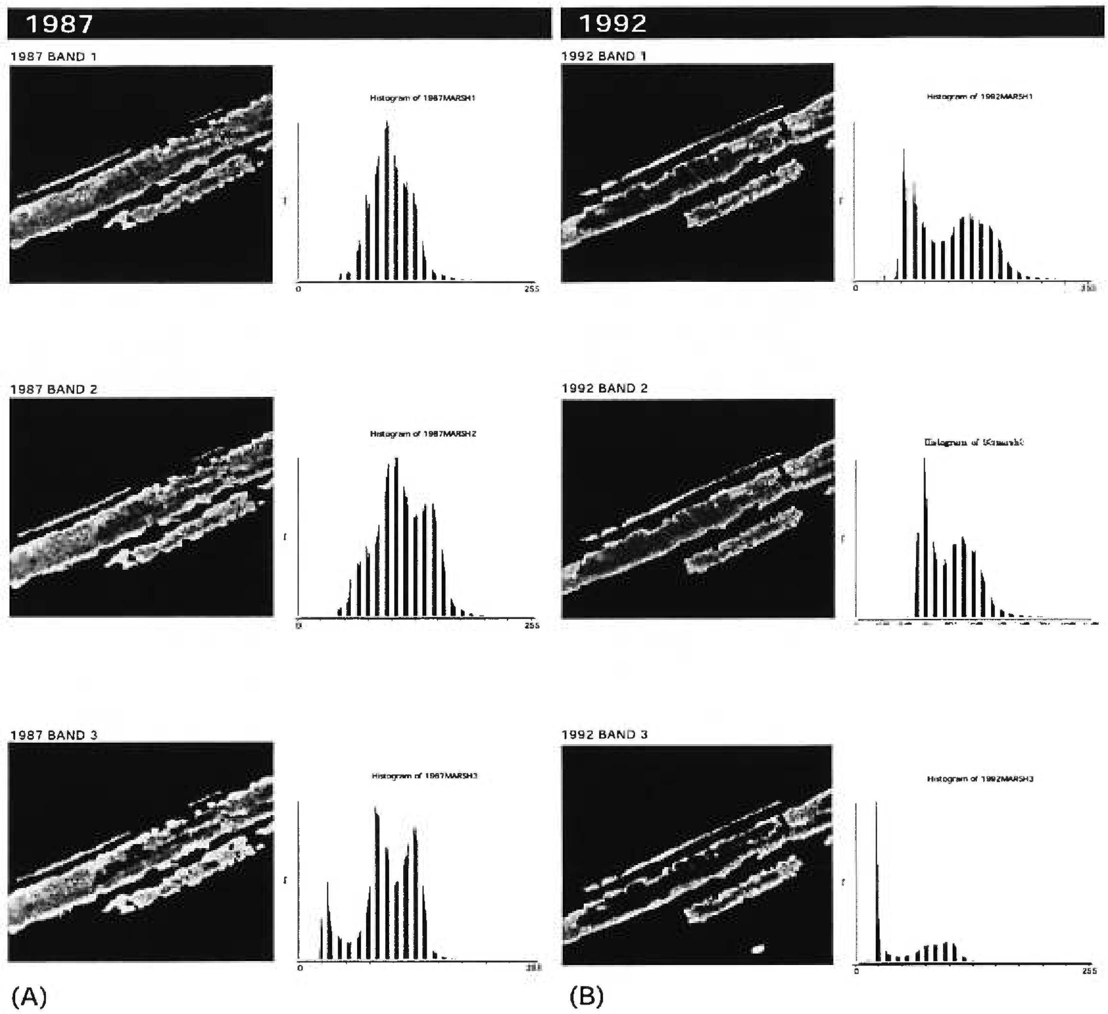


Figure 4.5: The extracted salt-marsh areas for (A) 1987 and (B) 1992 and their corresponding histograms.

together to provide the final classification at each particular date (1987 and 1992).

This proposed technique was applied on both SPOT XS images of 1987 and of 1992. The following parts explain, in more detail, the procedures followed in applying this technique.

- ***SPOT XS 1987 classification***

The masking processes yielded three XS images for each date; the first is the original image containing the land areas after masking out the salt marsh and the built-up zones, the second contained the salt marsh areas, and the third contained the built-up zones only. Each of these images was classified using two techniques: supervised and unsupervised (clustering) classifications. The resulting supervised classification of the land areas image gave a higher level of accuracy than those of the unsupervised techniques. The unsupervised classification of the separated built-up zones and the salt marsh areas, on the other hand, attained a higher level of accuracy than by applying the supervised technique.

First, the supervised classification of the land areas of 1987 was based on nine classes: irrigated agriculture (a and b), orchards, ploughed fields (a and b), dunes, natural vegetation, quarries, and bare soil. The spectral signature mean plot of the selected training areas for the nine classes is traced in Figure 4.6. Based on this, a maximum likelihood classification (MLC) was then applied to classify the whole image of land areas.

Before conducting the accuracy assessment procedures some of the produced classes were combined into one class to have a total of seven classes instead of nine for the land areas image. These two classes are irrigated agriculture (a) and (b); they were aggregated because of their spectral nature delineated in the signature comparison plot (Figure 4.6). It was very difficult to differentiate these classes from each other due to their spectral similarity in the three bands of the SPOT XS scene. The accuracy assessment was then carried out based on 35 randomly distributed points[5], which revealed an overall accuracy of 82.86%.

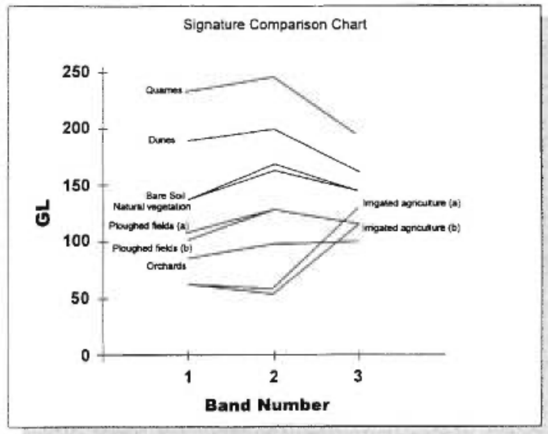


Figure 4.6: The signature mean plot for the land areas for the 1987 SPOT XS image.

Second, the unsupervised classification of the salt marsh areas image was conducted. This classification produced seven classes which included flooded areas, salt march vegetation (sparse and dense), bare soils, natural vegetation, quarries and construction sites. The accuracy assessment of the classification was then conducted based on 70 randomly distributed points[6]. This assessment resulted in an overall accuracy of 88.57%. This resulting high accuracy was expected since the unsupervised classification is spectrally based, and conducting it on the separated areas of almost one spectral class would lead to higher accuracy.

Third, the same steps of conducting unsupervised classification and accuracy assessment procedures were repeated for the built areas. The classification procedure produced three classes: built-up areas, activity areas, and construction sites with an overall accuracy of 90.00%.

[5] The randomly distributed points are then located on the ground and the percentage of each class is measured and cross-tabulated in the form of a contingency table to compare it with the corresponding percentages from the classification result in order to estimate its accuracy.

[6] The number of points is doubled in the unsupervised classification accuracy assessment because of the nature of this classification method that is not dependent on previously selected training sites.

Finally the products of the three classification procedures were all superimposed in one thematic map. The resulting classes and their corresponding IDs are presented in Table 4-1.

Table 4-1: The resulting classes from the classification procedures and their corresponding IDs

ID	class name	Description
1	crops	crop-cultivated land
2	orchards	orchard plantation
3	ploughed	prepared for agriculture
4	dunes	coastal sand dunes
5	natural veg.	sparse natural vegetation
6	quarries	quarries and construction sites
7	bare soil	open land, including pasture land
8	urban	the urbanized areas
9	activities	areas surrounding the urbanized areas
10	flooded	inondated salt-marsh areas
11	dense s.m. veg	dense salt-marsh vegetation
12	s.m. veg.	salt marsh vegetation

The training sites for supervised classifications were on-screen digitized on a False Color Composite (FCC) image combining the three bands of the SPOT XS 1987 with a beam of Red, Green and Blue (RGB) for bands 3, 2, and 1 respectively (Figure 4.7).

It is worth mentioning that the delineation of built-up areas and salt-marsh areas for masking and separation into individual images were conducted on the SPOT high-resolution panchromatic image (10 x 10 meters). It therefore facilitated the burden of spatially identifying small built-up and salt marsh areas.

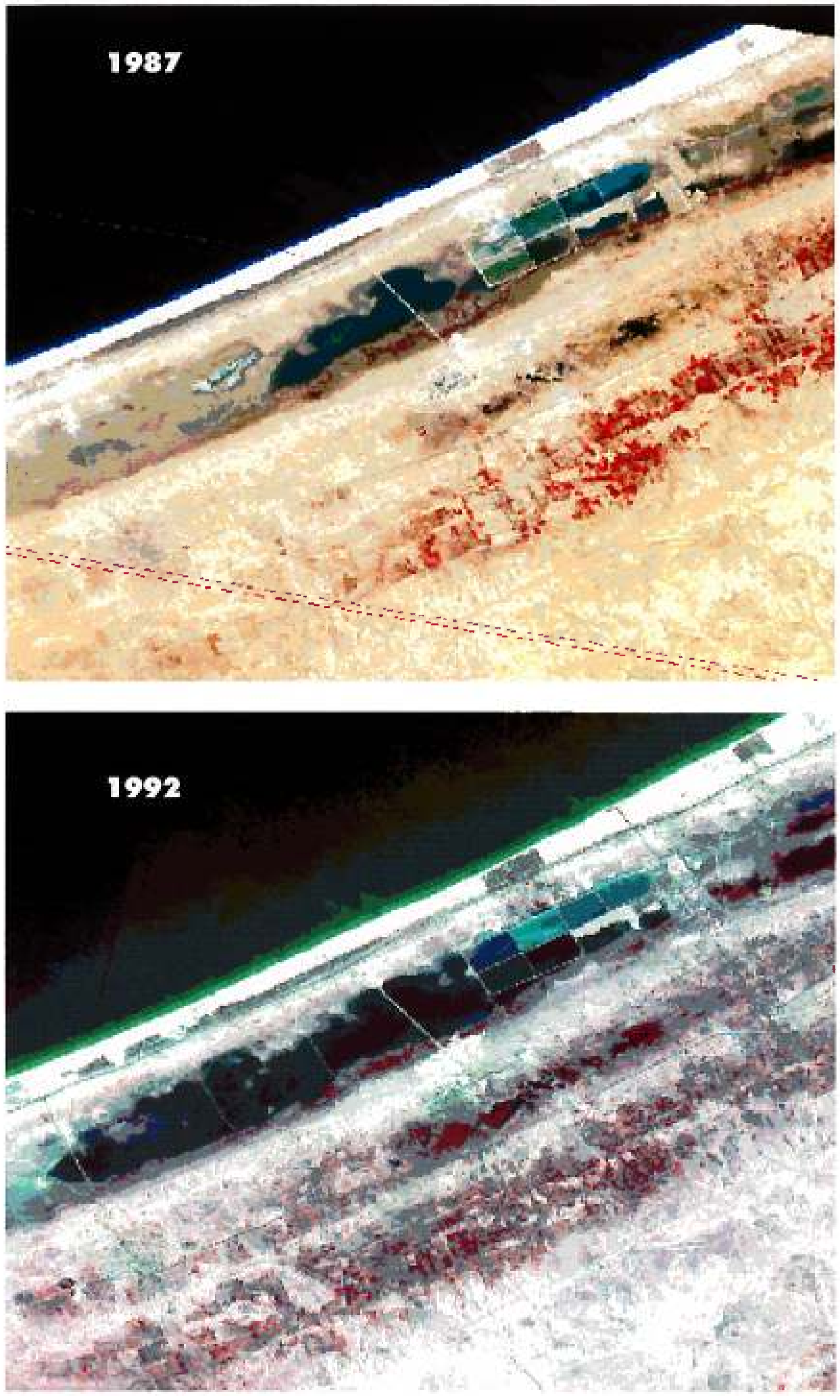


Figure 4.7: False color composite of the SPOT XS images for 1987 and 1992

- ***SPOT XS 1992 classification***

The above mentioned image processing work was applied to the corresponding 1992 SPOT XS image. Contrary to the 1987 classification, the supervised classification of the land areas, salt marsh, and built-up areas gave higher accuracy levels than the former utilized unsupervised classification.

Training sites for signature extraction was applied for each image, which resulted in three plots for signature comparisons (Figure 4.8 (a), (b), and (c)). The accuracy assessment gave an overall accuracy of 82.601% for land areas, of 97.88% for the built-up areas, and of 90.27% for the salt-marsh areas. The final classification tabulated results and classes with their corresponding IDs are the same as those produced for the corresponding SPOT XS of 1987.

c. *The aerial photographs*

Sets of aerial photographs of scale 1:25 000 were collected for September 1955 and November 1977. Photo mosaics were mounted in order to specify the study area and to identify the existing land uses. Stereoscope analyses were carried out in order to magnify specific areas and to simplify features identification. The extracted land use features at both dates are summarized in Table 4-2.

Two methods were used to automate these features, in both land use maps, useful elements such as roads intersections, railway lines, and reference buildings and specific land formations were also identified and digitized in order to facilitate mosaic preparation and registration procedures thereafter. The traditional method was applied to the 1977 photo set, in which all identified features were traced by hand on separate layers, coded, and then digitized using the A0 tablet with AutoCAD software. Every feature was given a code and was drawn as closed polygons on its specific layer. In the second method, which was applied to the 1955 photo set, each photo frame was digitally scanned and saved as an image file on disks. The produced images were therefore displayed separately with IDRISI software,

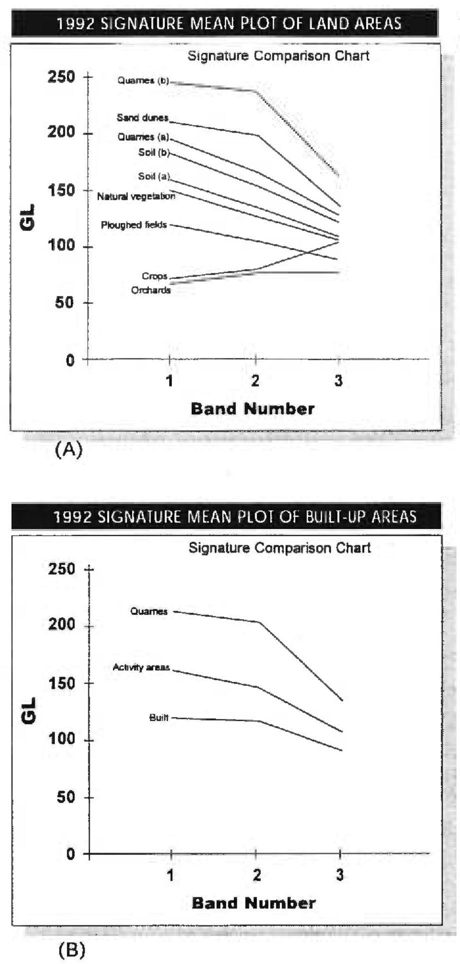


Figure 4.8: Signature mean plots for (a) land areas, (b) salt-marsh areas, and (c) land areas of the SPOT XS scene of 1992.

Table 4-2: The extracted land uses from the aerial photographs of 1955 and 1977.

ID	class name	Description
1	dunes	coastal sand dunes
2	crops	crop-cultivated land
3	orchards	orchard plantation
4	ploughed	prepared for agriculture
5	background	open land, including pasture land and sparse natural vegetation
6	urban	the urbanized zones including built-up and the surrounding areas
7	flooded	inondated salt-marsh areas
8	s.m. veg.	all salt marsh vegetation classes

by which every feature was consecutively on-screen digitized (traced). In this method, features identification was clear, as it was possible to flexibly zoom in and out the image at any time. Further features identification was carried out using the stereoscopic manipulation of the corresponding photo frames in parallel. Later on, the produced vector frames were exported to AutoCAD where the mosaic was piled in order to fuse the frames of the study area together.

The advantage of the former method was the computer capabilities independence of the procedure. The method does not need high performance computer equipped with high capability display and storage devices. On the other hand, the percent error is relatively high due to the accumulative nature of this procedure. The percent error in tracing the identified features is added to that of the digitizing process. However, in the second method, the error can only occur in the digitizing procedures. It also showed notable time and effort saving. The only perceived drawback in this method was the large amount of files, which needed remarkable generation time and larger disk storage space.

Each feature class vector file was then exported for each date separately to the ARC/INFO software on the UNIX platform via DXF[7] file format. For each date, polygons of every class were labeled with a centroid point and an ID code. Automatic error detection enabled the detection of unlabeled polygons and the undesired dangles[8] and pseudo[9] nodes. All these errors were therefore manually corrected. It has to be noted that the export/import processes from and to different software and platform affected to a great extent the time of data entry and preparation. Data processing time may be notably reduced provided one software that have digitizing capabilities, and that can provide methods for the on-screen digitization of scanned aerial photographs, including vector files editing and geometric corrections of geographic positions.

Polygons of all classes were then merged to form one vector coverage. The two dates coverages were then converted into the GRID[10] raster format with cell resolutions of 20m x 20m. In GRID, they were registered to the base map using selected Control Points (CPs) well distributed all over the grids. The same procedure was applied to both dates (1955, and 1977) which resulted in an average overall RMS[11] error of 0.15 pixel in both the X and the Y directions.

4.2.3.Data synchronization

The classification of the satellite images of 1987 and 1992 resulted in 12 classes, while the classes of the processed aerial photographs of 1955 and 1977 were only 8 (Figure 4.9). Class aggregation of the satellite images was therefore carried out taking into consideration the change that might have occurred in the

[7] Drawing Exchange File.
[8] Any arc endpoint not connected to another arc.
[9] The point at which an arc connects to itself (a loop) or to only one other arc.
[10] GRID is a raster- or cell-based geoprocessing tool that is integrated with ARC/INFO.
[11] Root Mean Square

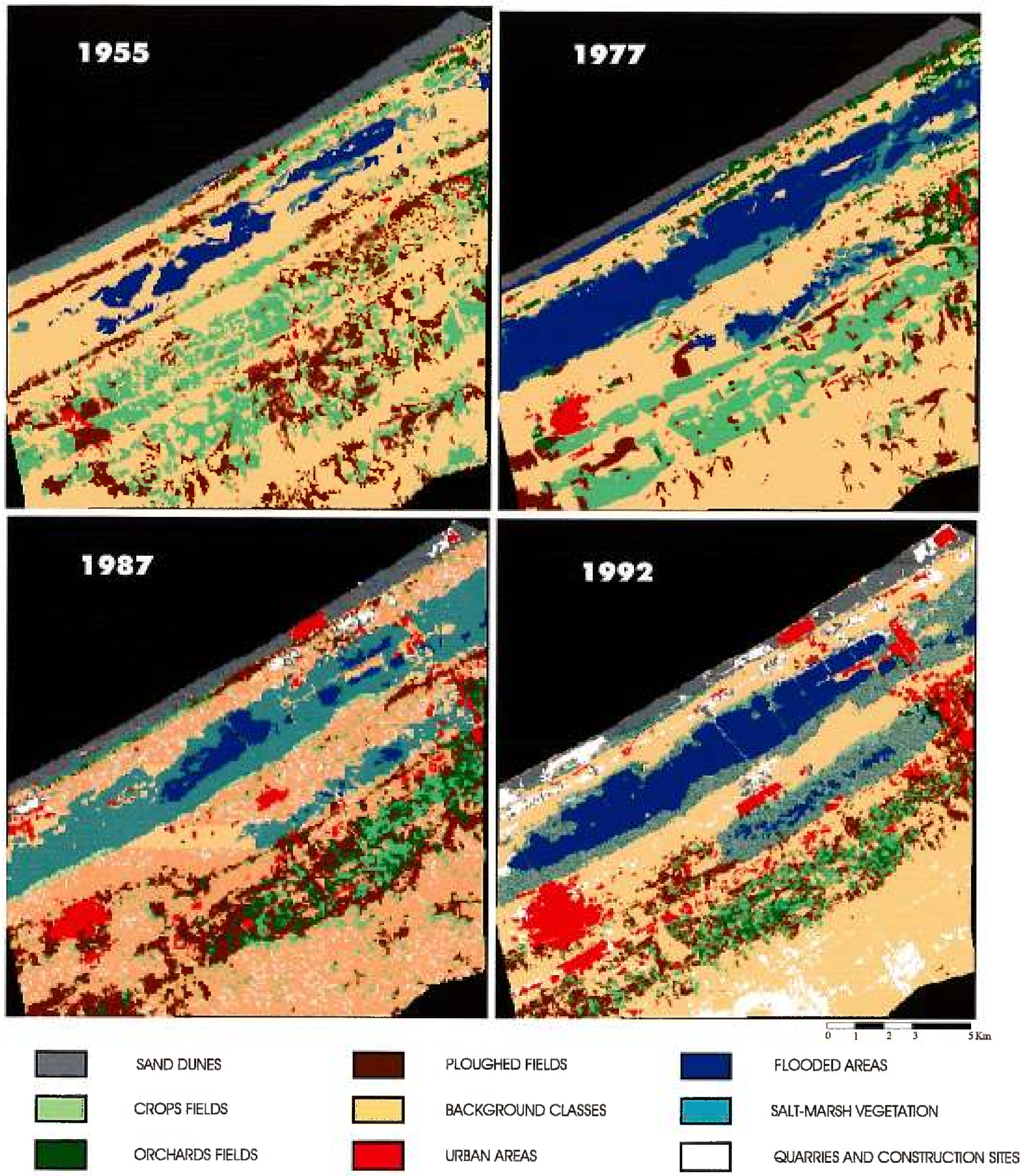


Figure 4.9: The produced land use/land cover classes of 1955, 1977, 1987 and 1992

region between different dates. The classes that were aggregated were: (a) the natural vegetation and the bare soil which were difficult to separate in the aerial photographs, (b) the urbanized areas and the activity zones because they actually constituted one agglomeration of the urban fabric, and (c) the sparse salt marsh vegetation and the dense salt marsh vegetation because they can be hardly differentiated in the aerial photographs. The resulting group of classes for all dates and their corresponding ID codes are presented in Table 4-3.

Table 4-3:The land use/land cover classes identified at all dates (1955, 1977, 1987 and 1992) and their corresponding ID.

ID	class name	Description
1	dunes	coastal sand dunes
2	crops	crop-cultivated land
3	orchards	orchard plantation
4	ploughed	prepared for agriculture
5	background	open land, including pasture land and sparse natural vegetation
6	urban	the urbanized zones including built-up and the surrounding areas
7	flooded	inondated salt-marsh areas
8	s.m. veg.	All salt marsh vegetation classes
9	quarries	quarries and construction sites

Furthermore, areas of less than 4 pixels in all directions were then eliminated in order to remove noise and undesired very small polygons. The four grids were therefore displayed in order to extract the desired study area which should totally fall within the frame of each date. A polygon of the study area was drawn and used as a clipping edge to extract the desired study area from the four dates grids. The final limitations of the study area was thus achieved as the area between longitude 29°23' and 29°33' East and latitude 30°49' and 30°58' North.

a. Selection of the study sectors

The study of the physiographic features of the study area is essential to landscape management. It provides information about landscape characteristics, forms, and visual amenities. It also gives an idea of how other natural resources function. Meanwhile, it helps understanding landform factors that might lead to development constraints or opportunities. Landscape units could be clearly identified for the pilot study area due to the variability in its physiographic attributes: edaphic, topographic and geomorphologic features. Beside these features, vegetation and land use attributes helped in characterizing such units.

In the extended territory represented by the study area, the topography becomes higher in an irregular fashion from the coast inland. The relief is characterized by successive undulations running more or less parallel to the coast. These undulations are in the form of calcareous rocky ridges alternating with depressions. The main features of the various physiographic units lead to distinction of three major physiographic systems (Ayyad and Le Floc'h, 1983, Kamal, 1988; Salem, 1989): a coastal system, which includes the beach and the coastal sand dunes; ridge-depression systems which includes the ridges, their gentle slopes and the more or less large depressions; the inland plateau system, close to the inland desert.

Based on these physiographic systems presented in detail in Ayyad and Le Floc'h (1983) as well as on the major land uses and human activities, five sectors were identified of the present pilot study area: (a) The coastal area, (b) the saline depression, (c) the Mariut ridge, (d) the non-saline depression, and (e) the Inland Plateau (Figure 4.10).

- ***The first sector: The coastal area***

This sector includes the beach, the coastal sand dunes, and Abu Sir ridge. The beach is approximately 200 m wide, it consists of white oolitic sand and is bordered from the south by dune rows. The coastal sand dunes are approximately 400 m wide. The active sand dunes lie

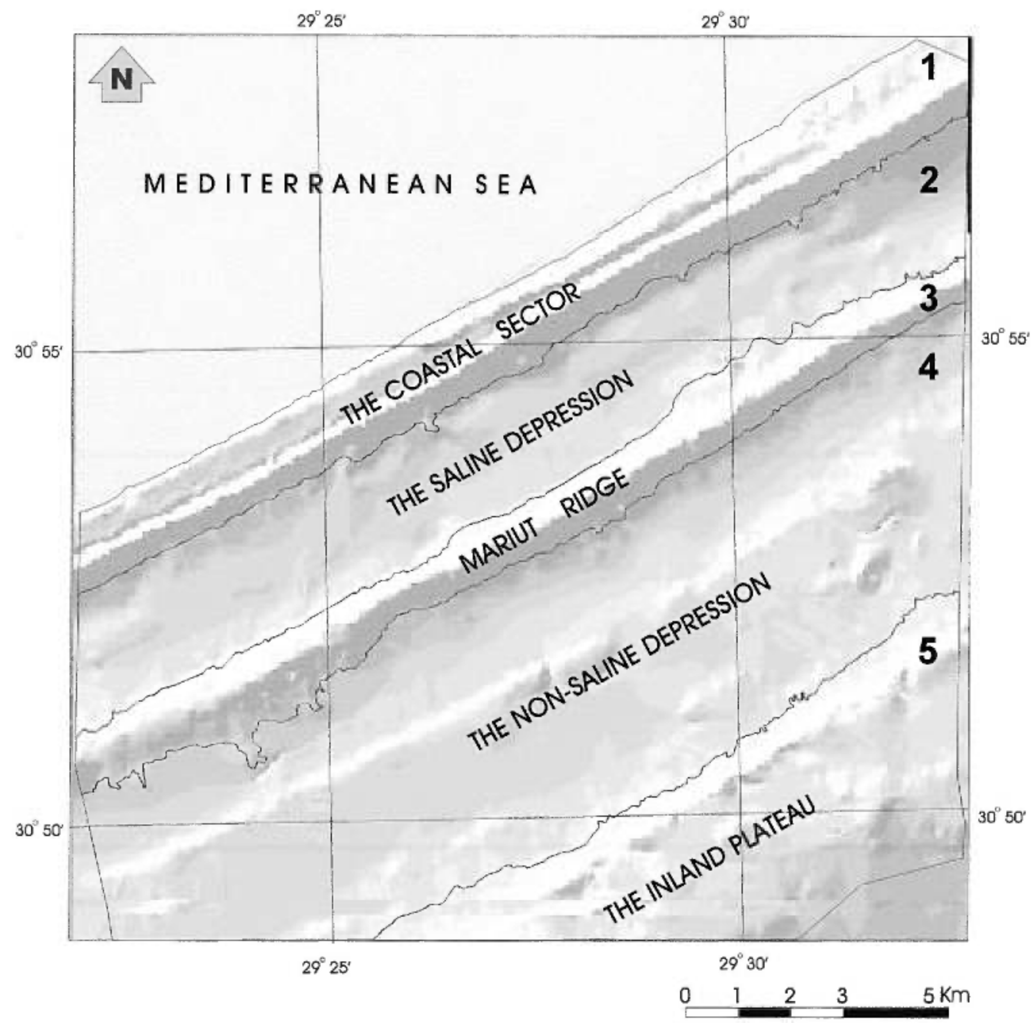


Figure 4.10: The selected five sectors (1) the coastal area, (2) the saline depression, (3) the Mariut ridge, (4) the non-saline depression, and (5) the inland plateau.

above the consolidated ridge in patches of white sand that contrast with the darker light brown compact base. The mean elevation of this ridge is 10 m. The Abu Sir ridge or the first rocky ridge is approximately 900 m wide. It extends parallel to the coastal sand dunes with an average elevation of 25 m. It is formed of limestone with hard crystallized crust. At the edge of the northern slope of the ridge lies Alexandria-Matruh coastal highway.

- ***The second sector: The saline depression***

The saline depression, or Mallahet Mariut is approximately 1.8 km wide and is periodically water-logged in some locations. The surface of the depression is mostly below sea level, and is filled mainly with brackish water and saline calcareous deposits of weathered and down-wash materials.

- ***The third sector: The Mariut ridge***

The Mariut ridge or the second rocky ridge is approximately 1.3 km wide, with an average elevation of 30 m. It is limited by the saline depression in the north and with the non-saline depression in the south. Similar to Abu Sir ridge (the first rocky ridge), it is formed of limestone with a hard-crystallized crust.

- ***The fourth sector: The non-saline depression***

This sector falls between the southern slope of the Mariut ridge in the north and the northern slope of the Sokkarah ridge in the south. The non-saline depression is higher in altitude than the saline depression (from 10 to 15 m above sea level); it is filled with clay soil and is suitable for cultivation. This depression accommodates the Burg El-Arab village and most of El-Hammam village. The extension of the non-saline depression represents the major area allocated for agricultural activities since many decades due to its fertility and accessibility.

- ***The fifth sector: The Inland Plateau***

It includes the Sokkarah ridge (the third rocky ridge) which is 1 km wide with an average elevation of 60 m above sea level. It is used as a rainwater catchement area for the cultivated land on its northern slope foot, and is composed of older oolitic limestone. The Inland Plateau, or the southern tableland, extends southwards and has an abrupt tilling towards the north. This system is highly dissected by natural drainage gullies, and is considered the main source of ground water recharge for the whole coastal plain.

4.2.4.The Analysis Strategy

The analysis is aimed at calculating the changes in the ecological and the visual attributes for each of the previously specified sectors. Five characteristics namely the number of patches, their size, their shape index, the land use/land cover diversity, and the activity (the degree of naturalness) were computed. The AML[12] computer programming language was used for customization of the ARC/INFO built-in functions.

a. The ecological characteristics

To calculate the size and the number of patches for each class the sectors were extracted from the classified grids for each date. Regions of the same class were then built, and the area and the perimeter for each polygon were calculated. The database of the created files was manipulated to contain information about each polygon's area and the number of polygons of each class. Figure 4.11 depicts the steps for these calculations. The shape index presented by Hulshoff (1995) was also calculated using the following equation (4-1):

$$S = \frac{1}{n}\sum \frac{P_{ni}}{4\sqrt{A_i}} \qquad \text{(Equation 4-1)}$$

[12] Arc Macro Language, a programming language that is specific to customizing ARC/INFO (UNIX) functions.

where n is the number of patches of class i, P_i and A_i are the perimeter and the area of patches in class i. If the landscape is composed of isodiametric (circular or square) patches, the shape index will be small, approaching to 1.00. The more the shape index deviates from 1.00 the more the patches deviate from an isodiametric shape which gives a measure of the complexity of patch perimeter as compared to a perfect square or circle. This indicates the type of land use/land cover existing in the landscape. Man-made land uses tend to be more regular (circular or polygonal) in shape than more natural landscape elements.

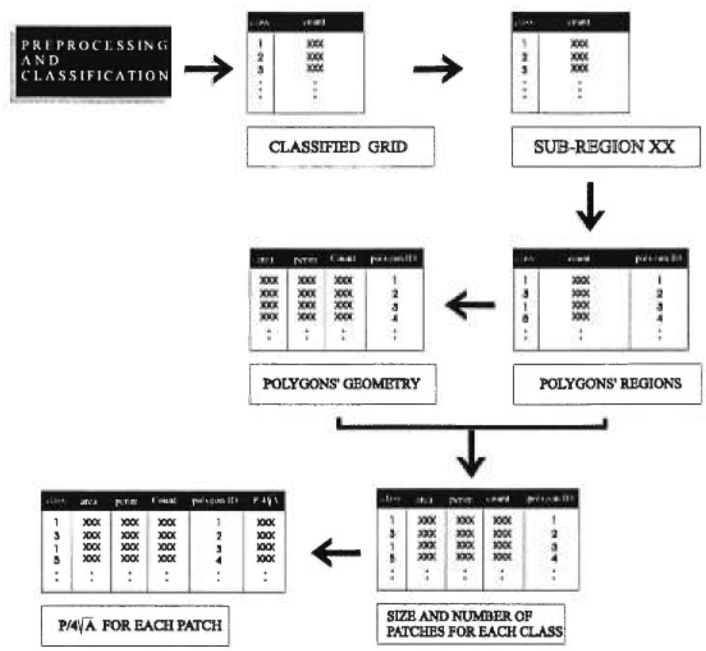


Figure 4.11: Main steps for calculating the ecological characteristics

b. The visual characteristics

Two visual characteristics were calculated for the study area: the activity, by which the degree of naturalness was identified, and the diversity by which the proportional distribution of different classes was calculated.

Figure 4.12 summarizes the method and the steps of calculation of each of these characteristics.

Three major classes of activities were recorded (Table 4-4), by which the degree of naturalization was identified according to the proportional distribution of its corresponding land use classes in a block of 100 x 100

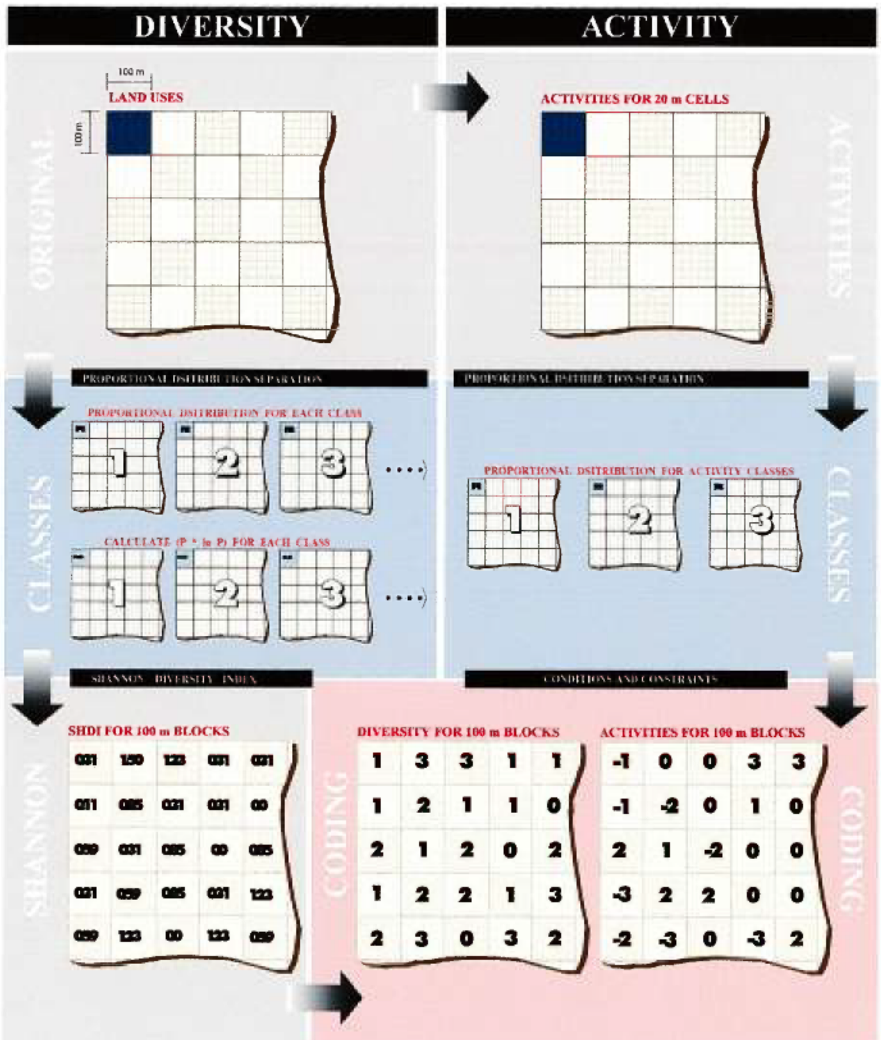


Figure 4.12: Major steps for the extraction of the visual attributes (diversity and activity) from the land use/land cover raster images.

Table 4-4: The proposed combinations of the activity classes

ID	code	Meaning
3	NA	Only natural classes
2	SN	Only semi-natural classes
23	SNNA	Combination between natural and semi-natural classes
123	EQ	Equal share between all classes (natural, semi -natural, and artificial)
13	ARNA	Combination between artificial and natural classes
12	ARSN	Combination between artificial and semi-natural classes
1	AR	Only artificial classes

meters (5 x 5 pixels) (Figure 4.12). The proportional distribution was calculated using the following equation (4-2):

$$PP = INT\frac{100}{x_i} * \sum N_i \qquad \text{(Equation 4-2)}$$

where PP is the percentage of the proportional distribution, INT is a function that transforms the result into integer values, x is the total number of pixels in each block (5 x 5 pixels for the present case), N_i is the activity of identification i.

The final output was produced to represent the existing land uses in the study area with its corresponding "degree of naturalness". Each resulting class was thus given a specific score which described its importance (Table 4-5) (Crawford, 1994).

Thereafter, the Shannon Diversity Index was calculated for the same 100 x 100 meters block according to the equation (4-3):

$$SHDI = -\sum P_i \ln P_i \qquad \text{(Equation 4-3)}$$

Where SHDI is the Shannon Diversity Index, i is the class, P_i is the proportional abundance of a class i in a specific study area. The value of P_i always varies between 0 and 1, therefore the logarithm of P_i will always be a negative value (except for 0 which will give infinity, and for 1 which will give 0).

Table 4-5: The selected activity group of classes.

ID	Code	Activity	Class_names	Class_ID
3	NA	Natural	Dunes	1
			Background classes	5
			Flooded areas	7
			Salt marsh vegetation	8
2	SN	Semi-	Crops	2
		Natural	Orchards	3
			Ploughed fields	4
1	AR	Artificial	Urban areas	6
		(non-natural)	Quarries and construction sites	9

The presence of the negative sign outside the summation function is needed in order to pertain a positive result for the index. A SHDI equal to 0 means that there is no diversity within the 100 x 100 meters block (only one class exists), and the greater the value of the index the more diverse the site. The SHDI calculation procedures are depicted in Figure 4.12.

For each sub-region, the proportional distribution was calculated for the 100 x 100 meters block for each class separately, and the first part of the equation (4-3) ($P_i \ln P_i$) was therefore calculated. The calculated results were then summed to produce one grid that contains the values of the SHDI. The cell size of the resulting grid is of 100 x 100 meters. These values were therefore classified in order to represent four scores of diversity. The final classification for the diversity is shown in Table 4-6.

Table 4-6: Different diversity classes extracted for the study area

code	Meaning	SHDI
ND	No diversity	0
LO	Low diversity	0 < SHID ≤ 0.5
IN	Intermediate diversity	0.5 < SHID ≤ 1
HI	High diversity	SHID > 1

Following all the analysis procedures, all the extracted attributes (ecological, visual, and socioeconomic) were coded as in Table 4-7 in order to be ready for the study of their interrelationships. For this, statistical methods were used to assess: (1) the significance of variations in the selected landscape attributes, and (2) the significance of variations between the same landscape attributes.

Table 4-7: Final codes of the selected landscape attributes

Code	Attribute name
	ECOLOGICAL
1	Number of patches
2	Size of patches
3	Shape of patches
	VISUAL - DIVERSITY
4	No diversity
5	Low diversity
6	Intermediate diversity
7	High diversity
	VISUAL - ACTIVITY (DEGREE OF NATURALNESS)
8	Artificial
9	Semi-Natural
10	Natural
11	Artificial/Semi-Natural
12	Artificial/Natural
13	Natural/Semi-Natural
14	Equal-share
	SOCIOECONOMIC - DEMOGRAPHY
15	Male/< 10 years
16	Female/< 10 years
17	Male/11-55 years
18	Female/11-55 years
19	Male/> 55 years
20	Female/> 55 years
	SOCIOECONOMIC - ECONOMIC ACTIVITY
21	Male/Agricultural
22	Female/Agricultural
23	Male/Quarries
24	Female/Quarries
25	Male/Industry and construction
26	Female/Industry and construction
27	Male/Tourism
28	Female/Tourism
29	Male/Transportation
30	Female/Transportation
31	Male/Social services
32	Female/Social services
33	Male/Others
34	Female/Others

CHAPTER V: RESULTS

In the present chapter the obtained results shall be traced and interpreted for each sector, in which ecological and visual characteristics of its landscape shall be presented and interrelated later in this chapter. Following the representation of results, the socioeconomic information also will be presented in order to reveal and to explain the changes and the forces that induced them and their impacts on each other. The results of the statistical analysis that assesses the variations in and between the selected landscape attributes shall also be presented later in this chapter.

These former characteristics shall be presented for three main landscape elements: (1) the natural areas, which include the background classes (bare soil, natural vegetation, and pasture land), the salt marsh areas (including the flooded areas, and salt marsh vegetation), and the sand dunes, (2) the agricultural land, including crop cultivation, orchard plantations, and ploughed fields, and (3) the built-up areas, which include the urbanized zones, the quarries and construction sites. As for the statistical analysis, it will consider the whole study area in the assessment of the obtained results. Before continuing with the detailed presentation of the results, the following table (Table 5-1) reviews the general changes that have occurred in the total areas of the main landscape elements in the study area.

Table 5-1: Percent total areas of each landscape elements in the study area.

TOTAL AREAS (%)					
ID		1955	1977	1987	1992
1	dunes	5.01	4.64	4.69	3.99
2	crops	16.82	11.18	2.69	5.24
3	orchards	0.88	3.92	3.29	1.39
4	ploughed	13.80	5.68	17.46	8.12
5	background	56.46	50.51	46.04	44.51
6	built-up	0.85	1.71	3.95	6.63
7	flooded	4.31	15.67	2.49	10.04
8	sm-veg.	1.88	6.68	18.60	13.14
9	quarries	0.00	0.00	0.79	6.95
	total	100.00	100.00	100.00	100.00

The cover percentages of the classes indicated in this table were estimated according to the classification procedures, and should be considered with caution since the seasonal differences may be inherent in the use of imagery of different dates. This is especially true if the dates occur in sharply different seasons (wet and dry seasons). In the present study the dates of the imagery are either at the beginning or at the end of the wet season. In this case some seasonal differences in the cover percentages indicated by the classification may be expected, but these would be less considerable than when the dates of the imagery are in the middle of both the wet and dry seasons. Thus, the differences recorded in the present study may then be attributed mainly to annual rather than seasonal changes.

5.1.Results of the change analysis

5.1.1. The first sector: The coastal area

a. *Ecological characteristics*

- ***The natural areas***

The most dominant land use/land cover classes in this region were both the sand dunes and the background classes which varied from about 34% to 41% of the total area (Figure 5.1).

With equal occupation between the background and the sand dunes in 1955, a clearly identifiable background matrix can be hardly perceived in terms of total relative area. However, in terms of connectivity the sand dunes (with its only one patch) have a higher degree, even though it does not cover all the region under investigation.

The sand dunes have decreased gradually from 1955 to 1992 to loose almost 12% of its area in the first sector. Furthermore, they have witnessed notable changes in their ecological attributes. This is reflected in the dissection and the perforation processes occurring to their only patch in 1955 and 1977, increasing its number to 54 patches in 1987 and 80 in 1992. This is associated

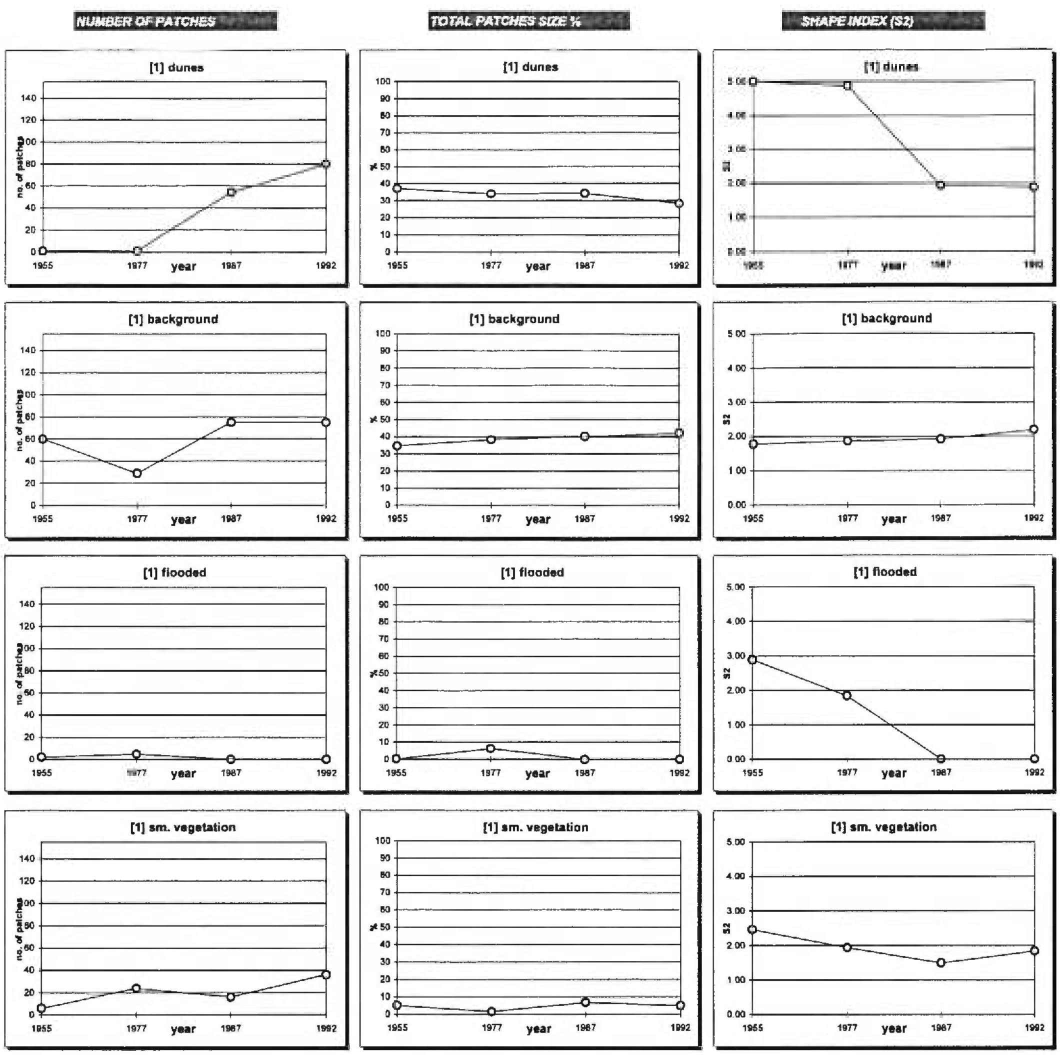


Figure 5.1: The change in the ecological characteristics of the classes of natural areas in the first sector (the beach, coastal sand dunes, and Abu Sir ridge).

with a correspondent decrease in their total area. Consequently, the evolution of their shape index shows that the natural, smooth edges of the existing patches were radically transformed into a more isodiametrical, artificial (man-made) shape.

On the other hand, the background classes have increased gradually from 1955 to 1992. The total number of its patches, however, decreased in

1977, increased later on in 1987 and maintained the same number in 1992. The shape index for the background classes was relatively increasing which provides an indication of evolution towards more convoluted boundaries. As it will be presented later on, this may be attributed to the decrease of the agricultural activities in general, a characteristic that occurred in this region in the period between 1955 and 1977, especially those related to orchard plantations.

Salt marshes, including all flooded and salt marsh vegetated zones, can be affected largely by seasonal changes, i.e. dryness of climate, for instance, can dynamically alter the size, the edge complexity, and the number of the existing patches. Therefore, the following findings are only applicable for the dates of the analyzed images. The flooded areas were not recorded in neither 1987 nor 1992. Only two patches with an average area of 0.32% of the total area existed in 1955. However, in 1977, an increase of 5.97% was detected with only 3 patches added. The shape index decreased from 1955 to 1977, changing the complexity of patch edges to a more isodiametric shape.

Salt marsh vegetation was distributed all over the region for the period under investigation. Its total area was fluctuating smoothly around an occupation of about 4%, and the patch numbers were increasing, which indicates a process of dissection and fragmentation. This is clearly reflected in the value of the shape index, which decreased gradually from 1955 to 1987 and then started to re-gain a little from its convoluted aspect later on.

- ***The agricultural land***

As previously stated, the agricultural land, in general, have decreased, and even have disappeared at specific dates. For instance, as depicted in Figure 5.2, the crop cultivation areas occupied 9.89% of the total area in 1955; this percentage dropped sharply to 0.72% in 1977 and totally disappeared in 1987. In 1992, it appeared again but with a very low average area percentage (0.19%). But the ploughed fields, prepared for agriculture, increased in 1987 and decreased in 1992 interchangeably with the crop-cultivated areas.

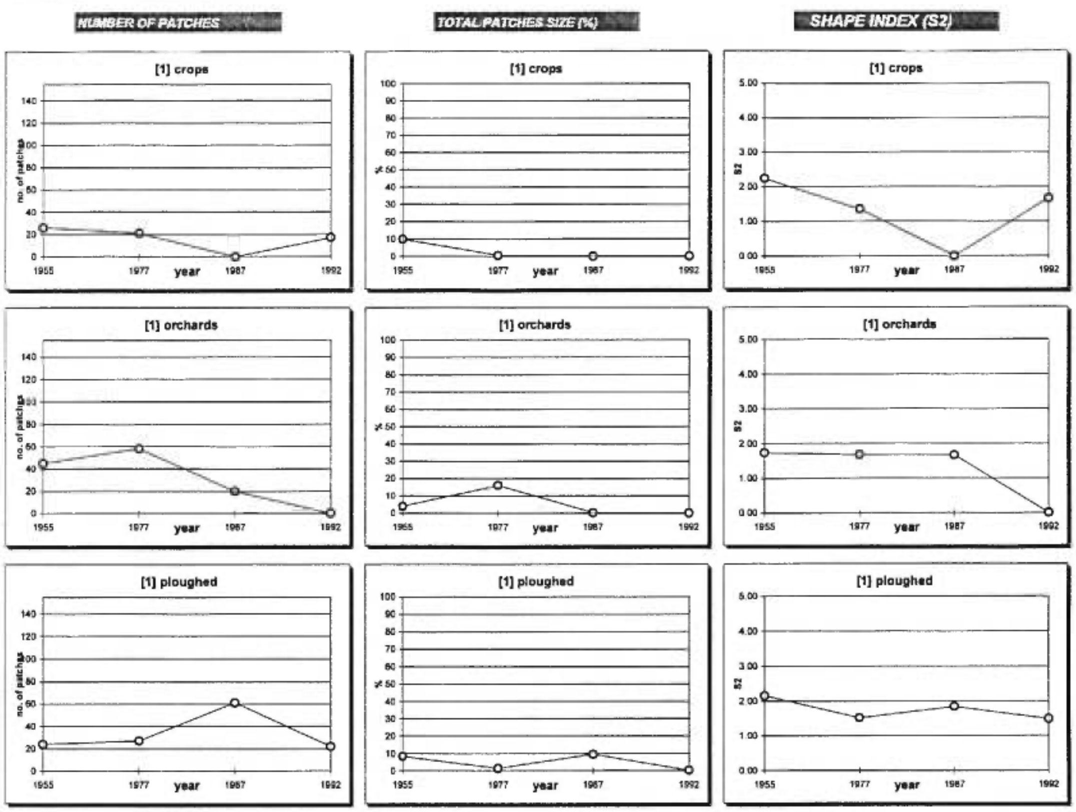


Figure 5.2: The change in the ecological characteristics of the agricultural land classes in the first sector (the beach, coastal sand dunes, and Abu Sir ridge).

It is important to note that the shape index reflected the evolution of the agricultural land management practices used during the past decades. It is clear that during the fifties no specific attention was given to the shape of the land or its edge complexity.

The agricultural fields followed mainly ridges' contours and salt marshes' boundaries. This resulted, more or less, in higher values of the shape index in 1955. However, this index decreased especially for patches of crop and ploughed fields consecutively in later years. This reflected the respect of land ownership and the application of "mechanized" agricultural techniques which divided the land into more regular shapes.

- ***The built-up areas***

The built-up areas in this sector have dramatically increased throughout the period under investigation. The area of the urbanized zones increased from 0.78% in 1955 to 5.78% in 1992 (Figure 5.3). Also, the number of patches gradually increased. In 1992, these patches tended to aggregate into a smaller number and to increase in average area. The shape index, however, did not change notably. Its average value of 1.45 reflected the polygonal shapes of urban areas.

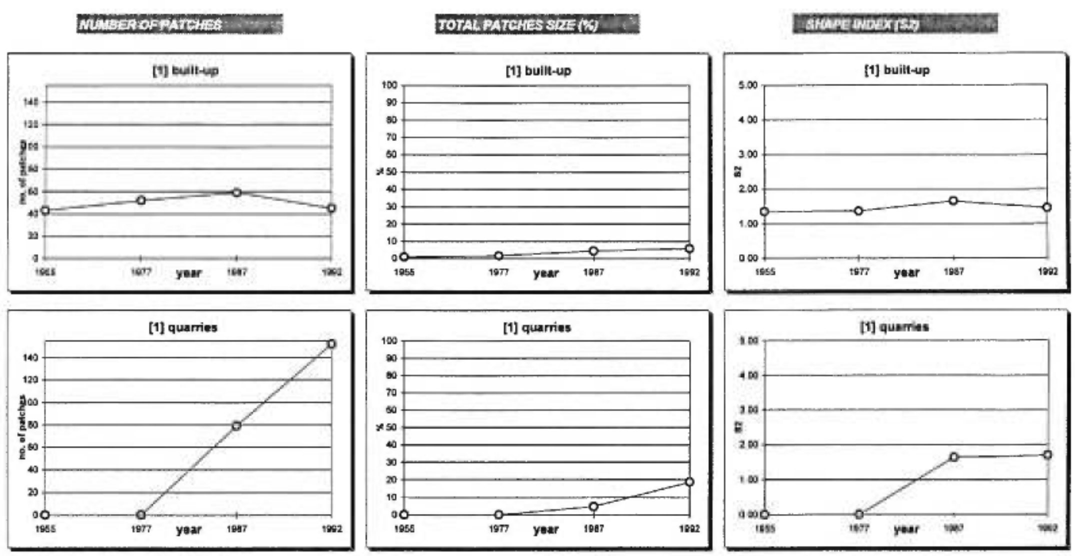


Figure 5.3: The change in the ecological characteristics of the built-up areas in the first sector (the beach, coastal sand dunes, and Abu Sir ridge)..

On the other hand, the area of the quarries and the construction sites increased remarkably in both number of patches and in average area. The latter changed dramatically from zero in 1955 and 1977 to 18.62% of the total area in 1992. This land use was presented in highly fragmented patches distributed within the sand dunes polygons representing construction activities of touristic villages, or on Abu Sir ridge representing limestone brick-making.

b. Visual characteristics

In this sector, special attention should be given to the visual qualities, because it is easily accessible by tourists and holiday-makers from different parts of Egypt. These visitors usually have different cultural backgrounds, and they either pass by this sector on their way further west (Marsa Matruh, Sidi Barrani, El-Alamein, ...etc.), or they spend holiday periods varying from a few days to the whole summer months. These visitors are mainly attracted by the beach for relaxation after the tedious rhythm of life in the city. In brief, the visual qualities of this sector should be considered as one of its valuable natural resources, and therefore be given high priority in the planning process.

As it can be noted in Figure 5.4, the sector under consideration is being transformed into a landscape of higher diversification, from natural cover to artificial land use. The loss is about 6.6% of its area, whereas the area of

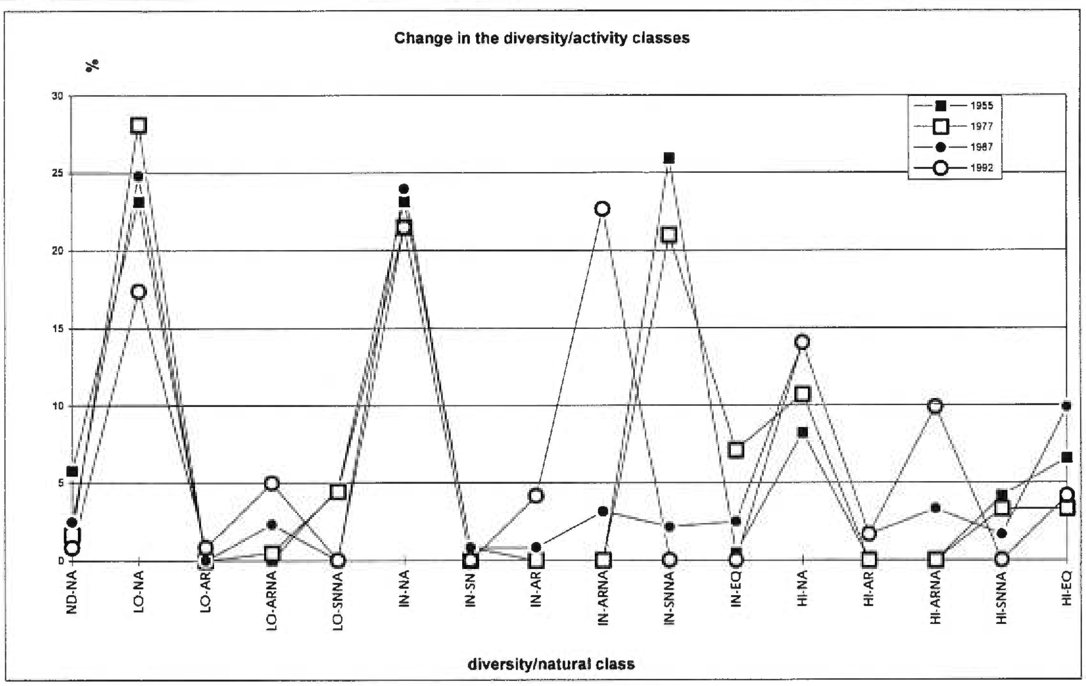


Figure 5.4: The change in the visual characteristics of the first sector (the beach, coastal sand dunes, and Abu Sir ridge)..

artificial/natural combination increased dramatically from zero to 37.5% over the 37 years period of investigation. Four combinations changed dramatically. The intermediate-diversity areas which include artificial and natural classes changed from zero to 22.2% of the total area, whereas the intermediate-diversity areas combining semi-natural and natural classes occupied 25.2% of the total area in 1955 but totally disappeared in 1992. On the other hand, the same trend can be found in the higher-diversity locations with respect to their smaller occupational area.

As shown in Table 5-2, this sector is losing 12.50% of its lower diversity areas. The values are deviating from the diagonal of the transition matrix, and

Table 5-2: Transition matrix of the percent change in land use diversity between 1955 and 1992 in the first sector (sand dunes, first depression and the first rocky ridge). (0) no diversity, (1) low, (2) intermediate, and (3) high diversity

		1992				
		0	**1**	**2**	**3**	total
1955	**0**	27.61	11.49	15.32	1.43	55.84
	1	6.82	5.83	6.68	0.66	20.00
	2	8.35	5.15	7.39	1.78	22.66
	3	0.56	0.31	0.59	0.03	1.50
	total	43.34	22.78	29.98	3.90	100.00

they were redistributed in 1992. On the other hand, Table 5-3 shows the transition of the naturalness classes from 1955 to 1992. 18.1% increase in the artificial classes is detected. This gained 15.7% from the natural classes in 1955, and the semi-natural classes decreased by 17.55%, which is transformed to natural areas (15.25%). The artificial/natural combination increased by 10.88% in 1992, this is mainly due to the transformation of the natural areas (9.15%). Finally, the semi-natural/natural combination witnessed a 7.98% loss mainly to natural areas (6.08%) from 1955 to 1992.

Table 5-3: Transition matrix of the percent change in the degree of naturalness between 1955 and 1992 in the first sector (sand dunes, first depression and the first rocky ridge). (1) artificial, (2) semi-natural, (3) natural, (12) artificial/semi-natural, (13) artificial/natural, (23) semi-natural/natural, and (123) equal share.

		1992							
		1	2	3	12	13	23	123	total
1955	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	1.25	0.03	15.25	0.00	0.87	0.10	0.07	17.58
	3	15.70	0.00	47.57	0.00	9.15	0.07	0.24	72.74
	12	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03
	13	0.24	0.00	0.28	0.00	0.07	0.00	0.00	0.59
	23	0.79	0.00	6.08	0.00	1.25	0.07	0.03	8.22
	123	0.10	0.00	0.59	0.00	0.14	0.00	0.00	0.84
	total	18.10	0.03	69.80	0.00	11.47	0.24	0.35	100.00

5.1.2.The second sector: The saline depression

As stated before, the salt marsh flooded areas and salt marsh vegetation are seasonally changing, and any detected changes can hardly be explained in terms of man-induced dynamics. To be more precise, these zones should be studied in depth in order to reveal their dynamics and to explain the changes in its components. However, obvious human-introduced changes can easily be detected because of their distinguished geometric shapes, and in this respect the obtained results will be presented and discussed.

a. *Ecological characteristics*

- ***The natural areas***

In general, the flooded salt marsh areas and those covered with salt marsh vegetation are exchanging occupation and therefore the most dominant class is always changing. It is obvious that they gained almost 60% of the background classes in the period between 1955 and 1977 (Figure 5.5), afterwards their average total area was around 82% with the dominance of the flooded areas in 1977 and 1992, and with dominance of the areas covered with salt marsh vegetation in 1987. Furthermore, the average area of flooded and salt marsh vegetation decreased from 89.12% in 1977 to 79.62% in 1992; this was accompanied by an increase of the background classes from 10.21% in 1977 to 15.21% in 1992.

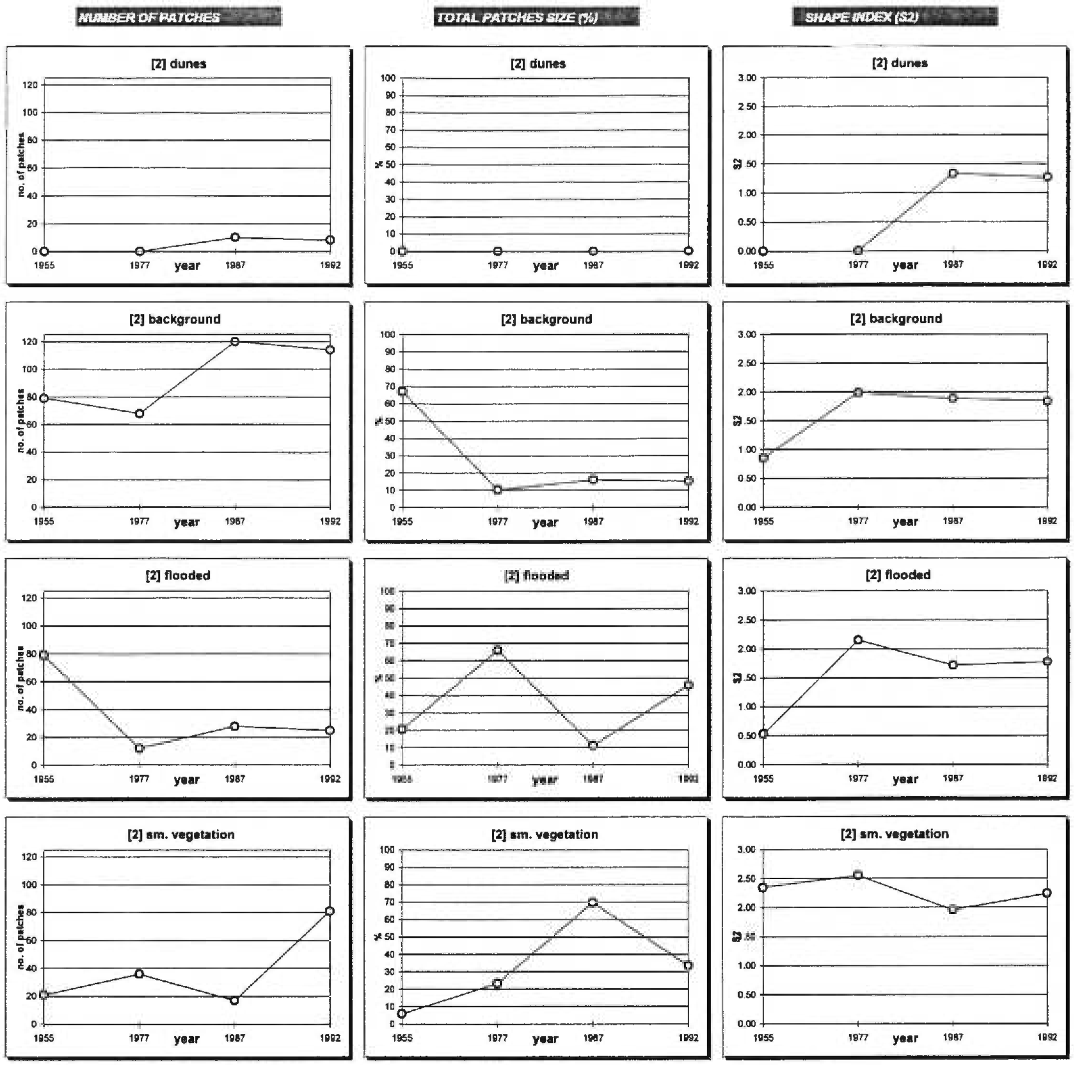


Figure 5.5: The change in the ecological characteristics of the classes of natural areas classes for the second sector (the saline depression).

As it will be explained later, the loss in areas of the flooded salt marsh areas and salt marsh vegetation can also be attributed to the introduction of several built-up patches connecting Burg El-Arab village to the coastal highway.

On the other hand, the shape index reflects lower values in 1955 for the flooded patches which increased and became of irregular shapes in 1977, and which decreased in 1987 and in 1992. This reflects a higher number of patches in 1955, fewer number in 1977 and more or less intermediate number in 1987 and in 1992. As the shape index for both the salt marsh vegetation and the flooded areas fluctuates, the more regular shapes introduced in the eastern zone of the sector by the operation of salt extraction are detected by the decreasing trend of the index, especially in 1987 and in 1992 when this change occurred. The same behavior is clear in the case of background classes in 1955; higher occupation percentage of 67.33% reduced the shape index, but it remained unchanged for the rest of the period under investigation.

- ***The agricultural land***

The saline nature of this region provided little opportunity for the agricultural use of land. In the fifties, the total area of the agricultural land constituted 6.25% of the region (Figure 5.6); this decreased gradually with the

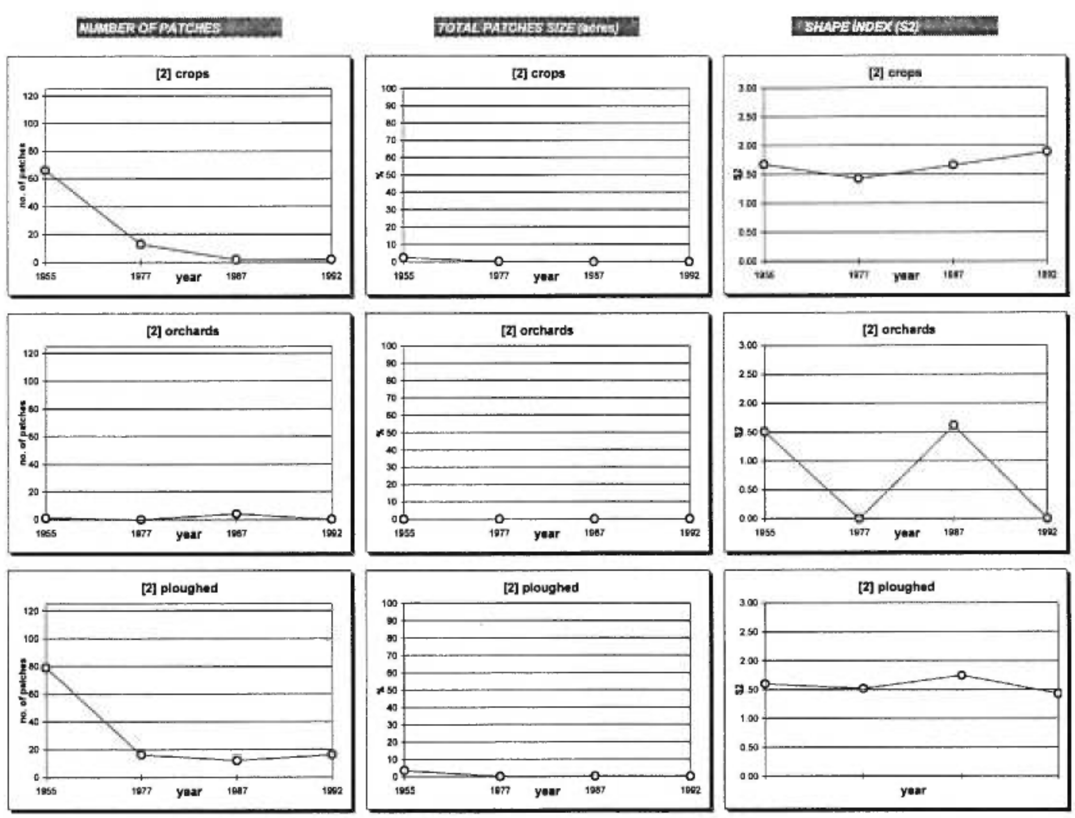


Figure 5.6: The change in the ecological characteristics of agricultural land classes in the second sector (the saline depression).

invasion of salt marsh areas to 0.16% in 1992. An increase in the shape index is recorded in both crop-cultivated and orchard-planted areas. In conclusion, the agricultural land in this region is almost disappearing either in terms of number of patches or in total area, and is substituted by either flooded areas and salt marsh vegetation or by urbanization, quarries and construction sites.

- ***The built-up areas***

Contrary to the agricultural land, all built-up patches increased steadily all over the region. As shown in Figure 5.7, the quarries, were not detected in both 1977 and 1955, increased to 2.78% in 1992. The number of built patches decreased in 1992 but their total area increased accordingly. The shape index shows this increase in irregular patches from 1955 to 1992.

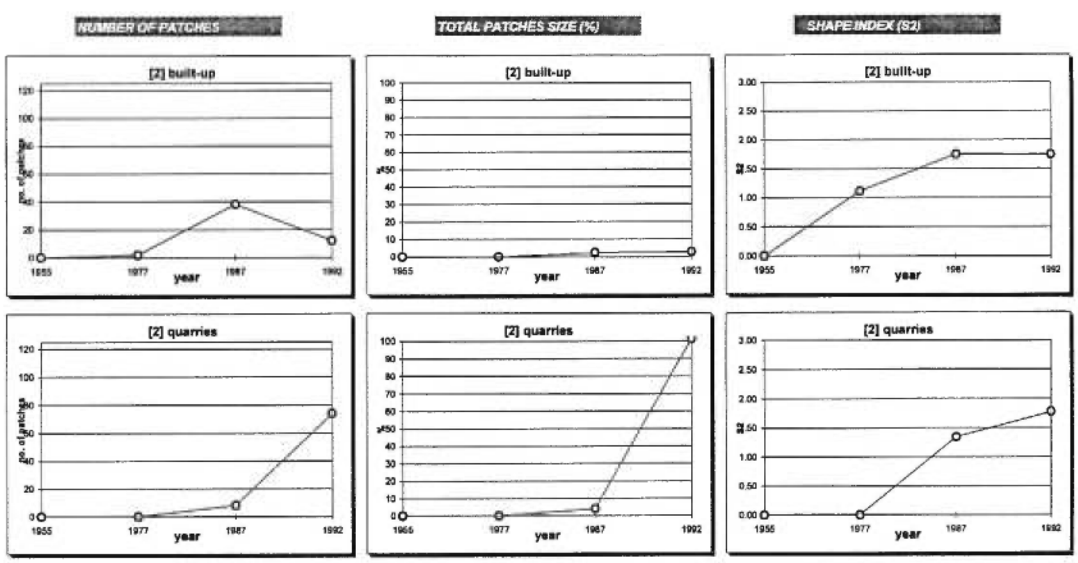


Figure 5.7: The change in the ecological characteristics of the built-up areas in the second sector (the saline depression).

This increase occurred in the area north of Burg El-Arab village in the form of slow expansion of its suburb. This expansion was mainly of several housing projects, which were implemented in dried salt marshes. Problems of rising water table could be detected.

b. Visual characteristics

It has to be noted that in this region, the transformation to non-natural land uses did have notable effects on its visual attributes. Notable changes were detected in the high-diversity natural areas which increased from 3.32% in 1955 to 11.63% in 1992 (Figure 5.8), and in the intermediate-diversity semi-natural/natural combination areas which decreased from 16.95% in 1955 to 0.1955% in 1992. On the other hand, natural areas with no diversity increased in 1977 to 28.8% and decreased again to 12.19% in 1992. This indicates a transformation of the homogeneous natural areas to more fluctuating, heterogeneous areas of combination between either natural or semi-natural classes. Furthermore, the transition matrices of the change in land use diversity (Table 5-4) and the degree of naturalness (Table 5-5) show no significant changes. There was only 4.66% loss of the "no diversity" areas to the low and the intermediate diversity classes. 2.25% gain was detected in the high-diversity

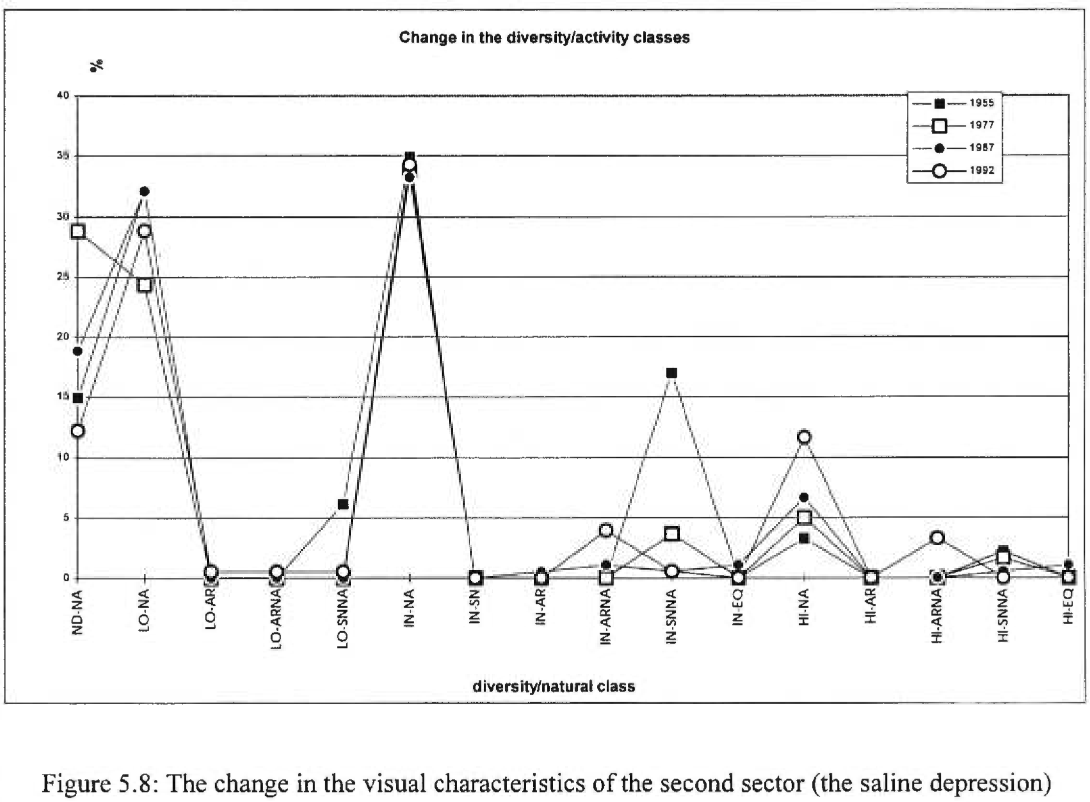


Figure 5.8: The change in the visual characteristics of the second sector (the saline depression)

areas. On the other hand, 3.3% loss in the natural areas was detected; this is due to a 3.26% gain from the artificial classes.

Table 5-4: Transition matrix of the percent change in land use diversity between 1955 and 1992 in the second sector (the saline depression). (0) no diversity, (1) low, (2) intermediate, and (3) high diversity

		1992				
		0	1	2	3	total
1955	0	40.54	9.84	12.47	1.31	64.16
	1	8.87	3.85	3.11	0.72	16.55
	2	9.95	3.85	4.39	0.65	18.84
	3	0.14	0.14	0.16	0.02	0.45
	total	59.50	17.67	20.13	2.70	100.00

Table 5-5: Transition matrix of the percent change in the degree of naturalness between 1955 and 1992 in the second sector (the saline depression).(1) artificial, (2) semi-natural, (3) natural, (12) artificial/semi-natural, (13) artificial/natural, (23) semi-natural/natural, and (123) equal share.

		1992							
		1	2	3	12	13	23	123	total
1955	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.05	0.00	2.77	0.00	0.09	0.00	0.00	2.90
	3	3.26	0.00	87.03	0.00	2.36	0.11	0.02	92.80
	12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23	0.02	0.00	3.83	0.02	0.36	0.05	0.02	4.30
	123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	total	3.33	0.00	93.63	0.02	2.81	0.16	0.05	100.00

From these results it may be concluded that the saline depression (the second sector) is maintaining most of its visual attributes, despite the introduction of some construction projects in the late eighties. The rate of decrease is not alarming in this sector. This may be attributed to the difficulties and the cost demanding of the utilization of the salt marsh areas. However, salt-extraction industries are present in this region, but their impacts may be more significant in areas more to the east. The impacts of such utilization and the changes in the salt marsh areas need more detailed future studies.

5.1.3.The third sector: Mariut ridge

a. Ecological characteristics

- ***The natural areas***

As the flooded areas of the second sector (the saline depression) increased in 1992 (Figure 5.9), the area that was occupied by salt marsh classes also increased and involved some of the northern parts of the third sector (Mariut ridge). Salt marsh vegetation increased notably from 1955 to 1992 from zero percent to 11.28%. The number of its patches increased in 1977 and 1987, and formed more fragmented

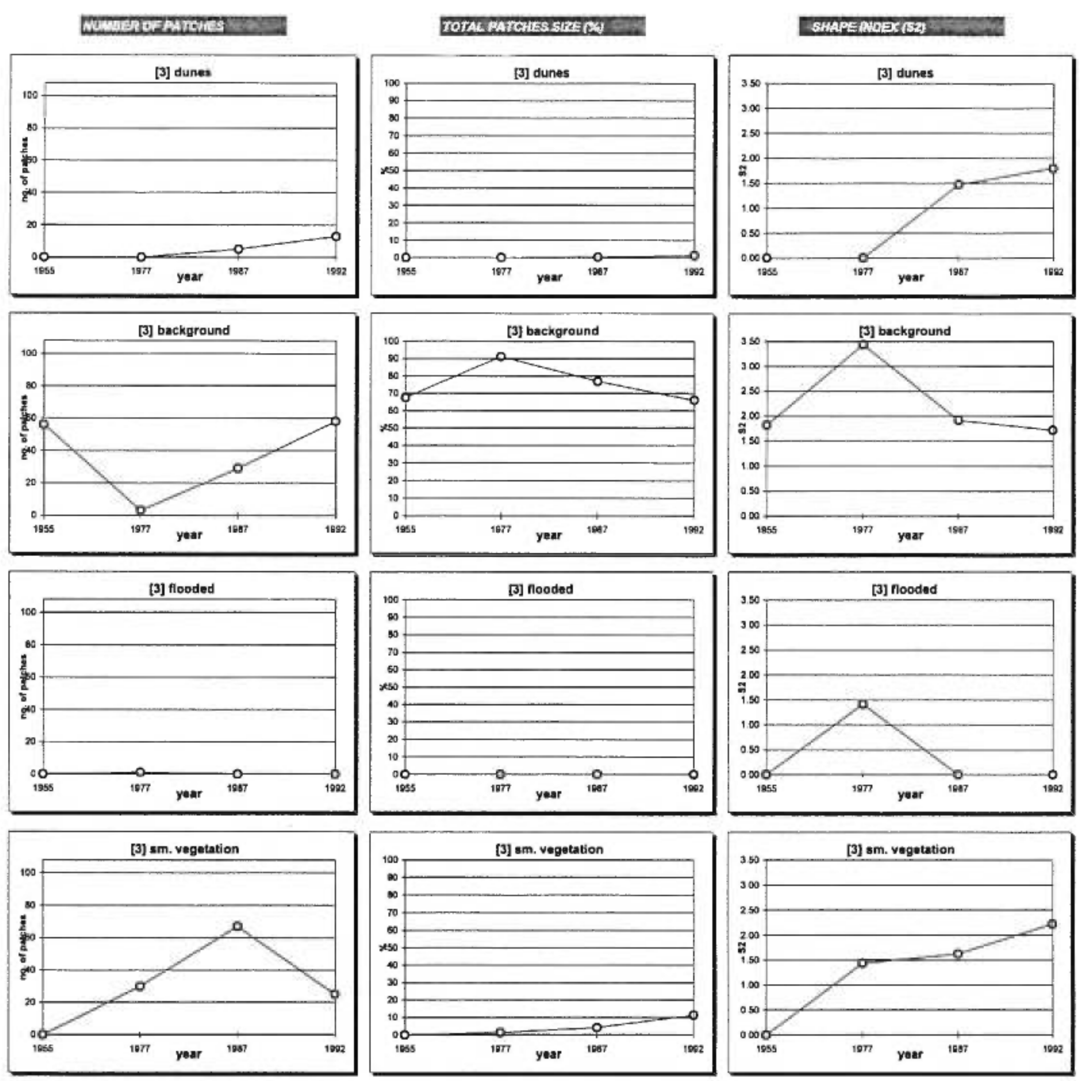


Figure 5.9: The change in the ecological characteristics in the classes of natural areas classes of the third sector (Mariut ridge).

patches of natural, convoluted shape. However, in 1992, it formed a fewer number of large patches. The shape index indicates a more natural process of change from, more or less, dissected and fragmented patches to convoluted and more coarse-grained areas of natural salt marsh vegetation.

On the other hand, the background classes occupied in 1955 a smaller area of numerous isodiametric patches. The total number of patches then decreased in 1977 which was associated with an increase in the total area (from 67.83% in 1955 to 89.95% in 1977), resulting in more connected background patches in 1977.

Later on, in the following years, there was an increase in the number of patches associated with a decrease in the total area; this indicated a process of dissection and/or fragmentation of patches, which was depicted in the decreasing values of the shape index from 1977 to 1992. The total loss in the area from 1977 to 1992 was transformed to classes of salt marsh vegetation and sites of urban development, quarries and construction.

- ***The agricultural land***

The area of crop cultivation dropped remarkably from 14.86% in 1955 to 0.06% in 1992 (Figure 5.10). This sector was occupied in the fifties by rain-fed agricultural fields; the shape of the fields was semi-circular or arc-shaped providing a means for harvesting rain water. These fields occupied about 31.16% of the total area in 1955 and decreased to 0.33 in 1992. The sudden increase in area and number of patches of the ploughed fields in 1987 was not reflected in a parallel increase in either crop-cultivated or orchard-planted fields in either 1987 or 1992. This lack of correspondence may be attributed to yearly changes in preparation or post-harvesting utilization of land for agricultural activity. The 1987 classified satellite image was acquired in April which can be considered a post-cultivation period. This calls for more frequent data in order to be able to detect seasonal changes especially in agricultural lands.

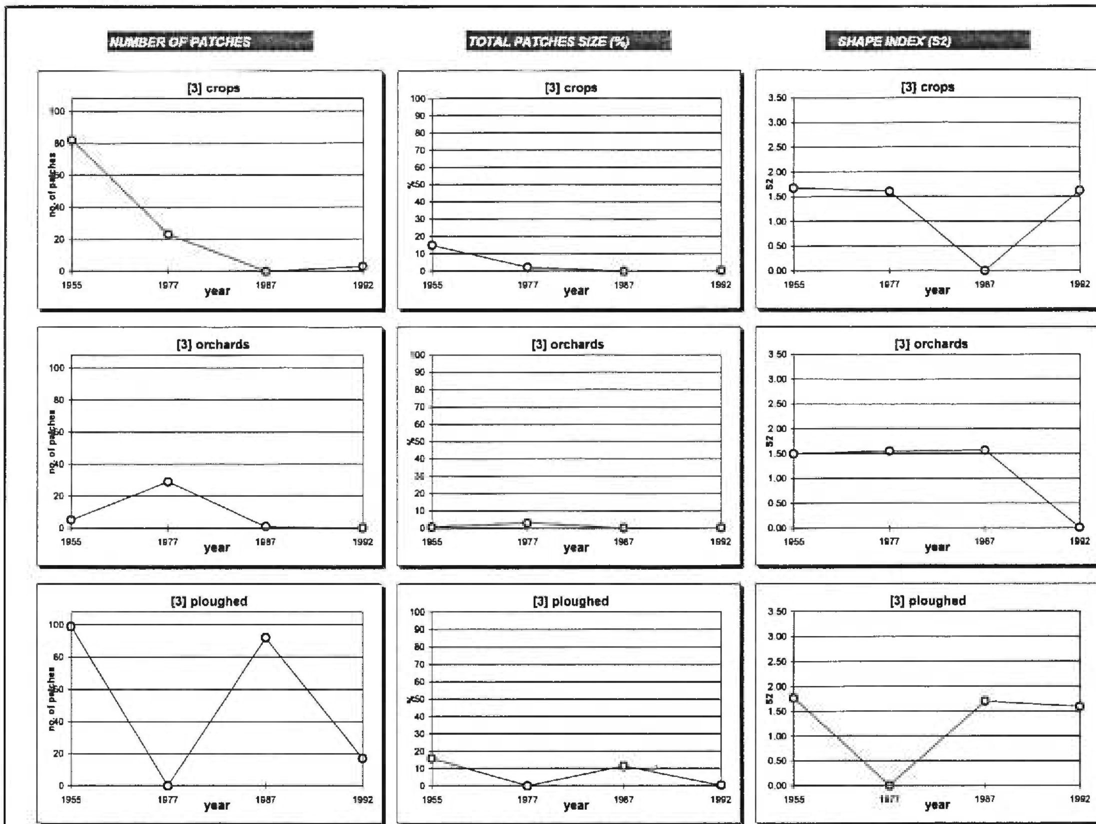


Figure 5.10: The change in the ecological characteristics of the classes of agricultural land in the third sector (Mariut ridge).

- ***The built-up areas***

The built-up areas increased from 1.49% in 1955 to 21.23% in 1992 (Figure 5.11). This increase could be identified as an urban expansion of the northern part of El-Hammam village, of the industrial establishments midway between Burg El-Arab and El-Hammam, and of the northern area of Burg El-Arab village. It could also be identified by the appearance of dispersed patches of quarries and construction sites all over the region. The former decrease in the background classes in this region is associated with the increase in the total built-up area. The increasing number of the patches of quarries explains the perforation process of the original background matrix, while the decrease in the

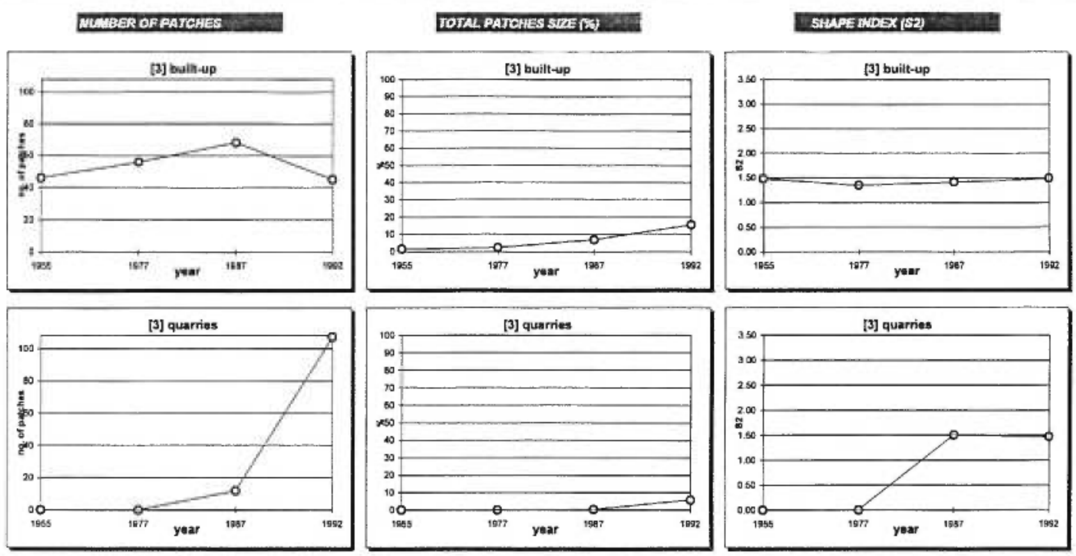


Figure 5.11: The change in the ecological characteristics of the built-up areas in the third sector (Mariut ridge).

number of built-up classes and the associated increase in its area assume a substitution of the background matrix with artificialized urbanized classes.

b. *Visual characteristics*

Due to the change between 1955 and 1977 in the total area occupied by agricultural activities, the "natural" areas with "no diversity" (one land use/land cover class) were absent in 1955 (Figure 5.12); they re-appeared in 1977 (19.4%) and decreased to 4.09% in 1992. Changes in two classes are also notable, first the increase in the intermediate diversity classes of artificial/natural combinations (from zero in 1955 to 13.89% in 1992), and second the decrease in the intermediate diversity classes with semi-natural/natural combination (from 44.54% in 1955 to 1.02% in 1992). The increasing trends of the artificial classes in different diversity values are also notable.

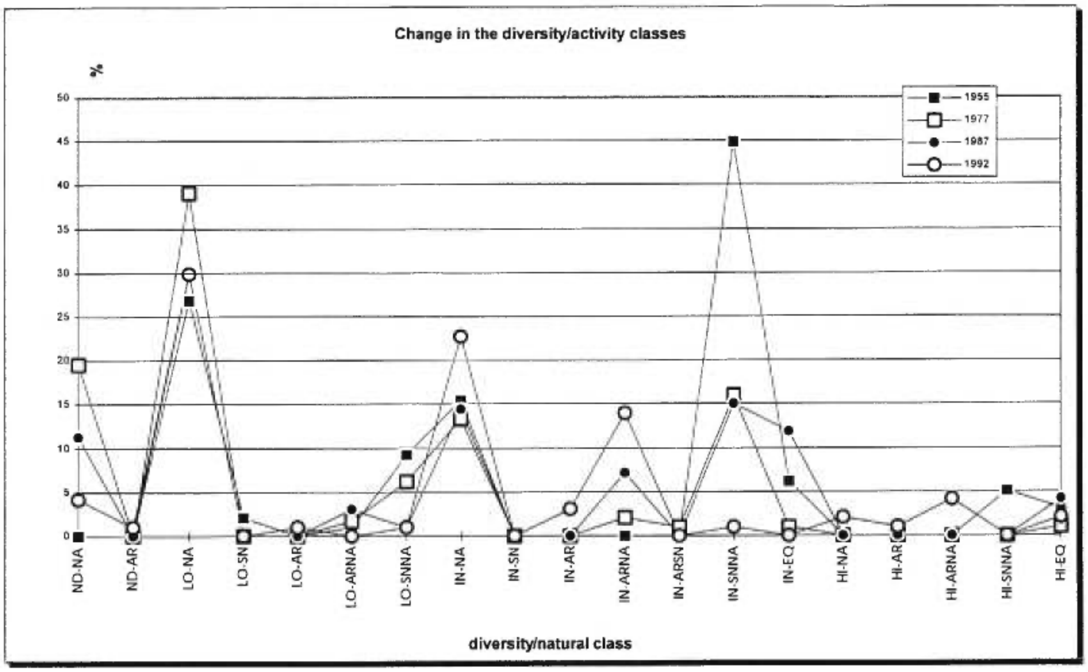


Figure 5.12: The change in the visual characteristics of the third sector (Mariut ridge).

In this sector, there was a 9.98% increase in the "no diversity " (one land use/land cover class) classes which was gained from low and intermediate areas (Table 5-6). An increase in these areas was also notable. On the other hand, the areas occupied with artificial activities increased from 0.31% in 1955 to 18.11% in 1992; this was mainly gained from the natural areas (11.23%) (Table 5-7) A loss of 24.78% was also notable in the semi natural classes from which 20.12% went to the natural areas. Also the artificial/natural classes increased by 8.12% on favor of the natural areas (6.00%).

Planning criterion for visual appeal may call for a less densified and less concentrated built-up and industrial zones, and more integration with natural and semi-natural classes, which may enhance visual attributes by increasing the diversity.

Table 5-6: Transition matrix of the percent change in land use diversity between 1955 and 1992 in the third sector (Mariut ridge). (0) no diversity, (1) low, (2) intermediate, and (3) high diversity

		1992				
		0	1	2	3	total
1955	0	26.97	7.71	8.36	0.70	43.73
	1	13.05	6.22	6.92	0.28	26.46
	2	13.14	8.26	6.55	0.42	28.37
	3	0.56	0.23	0.65	0.00	1.44
	total	53.71	22.42	22.47	1.39	100.00

Table 5-7: Transition matrix of the percent change in the degree of naturalness between 1955 and 1992 in the third sector (Mariut ridge).(1) artificial, (2) semi-natural, (3) natural, (12) artificial/semi-natural, (13) artificial/natural, (23) semi-natural/natural, and (123) equal share.

		1992							
		1	2	3	12	13	23	123	total
1955	1	0.10	0.00	0.21	0.00	0.00	0.00	0.00	0.31
	2	3.21	0.00	20.12	0.00	1.40	0.00	0.05	24.78
	3	11.23	0.00	50.39	0.00	6.00	0.10	0.36	68.08
	12	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	13	0.31	0.00	0.83	0.00	0.00	0.00	0.00	1.14
	23	2.74	0.00	0.00	0.00	1.71	0.16	0.05	4.66
	123	0.47	0.00	0.36	0.00	0.16	0.00	0.00	0.98
	total	18.11	0.00	71.91	0.00	9.26	0.26	0.47	100.00

5.1.4. The fourth sector: The non-saline depression

a. *Ecological characteristics*

- ***The natural areas***

The most remarkable change in this region is the increase in the total area of the salt marsh from total absence in 1955 to 12.29% in Figure 5.13. The salt marsh vegetation alone increased to 10.87%. The flooded areas increased to 3.00% in 1977 with an associated increase in the salt marsh vegetation of 3.86%. This means that the salt marsh vegetation dominated the salt marsh area in both 1987 and 1992. On the other hand, the background classes increased from 49.15% in 1955 to 50.27% in 1977. It then decreased to 41.42% in 1987

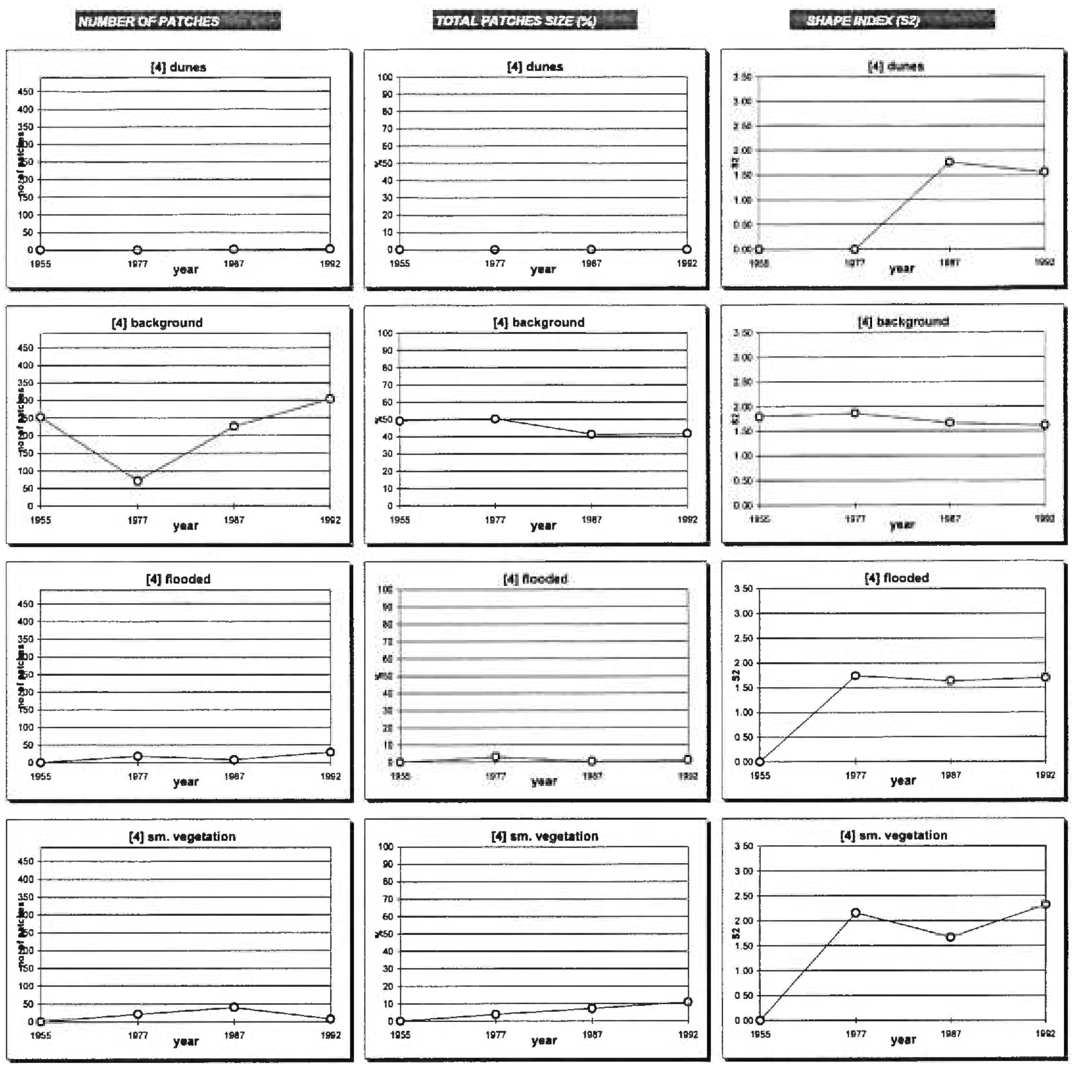


Figure 5.13: The change in the ecological characteristics of the classes of the natural area in the fourth sector (the non-saline depression).

and remained almost unchanged in 1992. The number of patches indicated an increasing trend of fragmentation from 1977 to 1992.

Again, the number of patches in 1955 was almost equivalent to that of 1977. This may be due to the fact that with the unmechanized agricultural practices in the fifties, the land was not "mechanically" subdivided, and was more or less circular in shape surrounded by man-made hills for rainwater harvesting. In 1977, a higher connectivity of the background matrix was achieved (lower number of patches with greater size) with a, more or less, convoluted shape indicated by the higher shape index values. In later years, the process of fragmentation and/or dissection was taking place. This is demonstrated by the increasing number of patches with smaller sizes, and with more or less isodiametric shapes (decreasing value of the shape index from 1.86 in 1977 to 1.61 in 1992).

- ***The agricultural land***

What is really contradictory to the National Plan of desert reclamation and to increasing the agricultural land of Egypt (refer to Chapter I: Introduction for more details), is the notable decrease in the total area allocated for agriculture from 49.4% of "vernacular" practices and rain fed agriculture in 1955 to 35.83% of "mechanized" and Nile-water irrigated agriculture in 1992.

The major decrease was in the total area of the crop-cultivated land, which dropped from 28.75% in 1955 to 6.53% in 1987 (Figure 5.14); it then increased to 12.76% in 1992. A tendency of increase of orchard plantation was recorded in 1977 and 1987. However, in 1992, the relative area was reduced to 3.41%, and apparently was substituted by crop-cultivation that increased from 6.53% in 1987 to 12.76% in 1992. However, these results are to be considered with caution because the comparison is here between closely related types of land use which have close spectral characteristics.

The area of ploughed fields, on the other hand, was reduced by 8.94% from 1955 to 1977.They witnessed a remarkable increase of 19.94% in 1987, and finally they lost 11.26% of their area in 1992. However, their increase in 1987 did not reflect an associated increase in the total area allocated for either crop cultivation or orchard plantation in the following years.

It has to be noted that the area of crop-cultivated land, although decreased in 1977, formed bulky patches in 1977, and it was highly fragmented

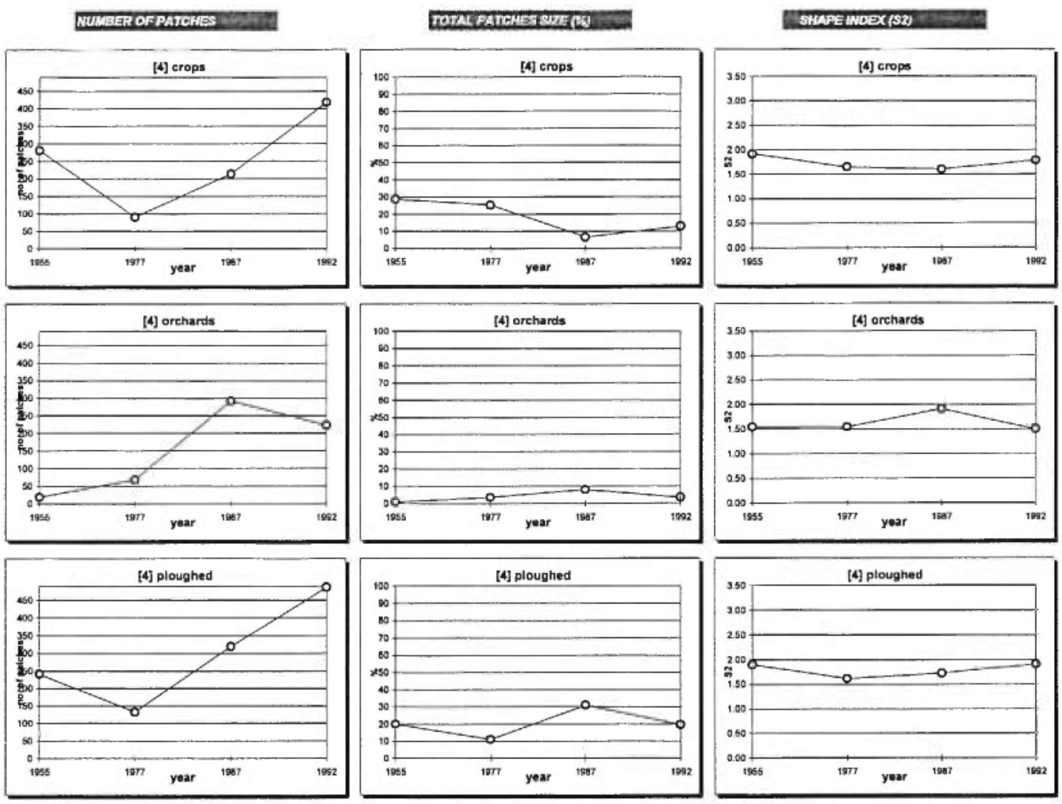


Figure 5.14: The change in the ecological characteristics of the classes of agricultural land in the fourth sector (the non-saline depression).

in both 1987 and 1992. Furthermore, its shape index indicated a transformation to convoluted shapes in 1992.

The patches of orchards kept increasing till 1987 when their shapes became more complex. However, in 1992, the increase in their total area was associated with a decrease in their number and their shape index.

- ***The built-up areas***

In this region, the built-up areas were mainly concentrated in the two villages of Burg El-Arab in the east and El-Hammam in the west. In the late eighties and in 1992, these areas not only expanded from their original locations but they appeared all along the connecting area between the two villages as well. A new core for urban growth, also expanding rapidly, was created south of El-Hammam, which was formerly a very small agglomeration named Abu El-Magd village. In 1992, this small agglomeration nearly merged with El-Hammam village. Furthermore, scattered settlements also spread south of the highway connecting both Burg El-Arab and El-Hammam at the fringes of the agricultural land.

As depicted in Figure 5.15, the urbanized areas increased remarkably from 1.45% in 1955 to 9.13% in 1992. This was associated with a proportional increase in their number of patches which could be observed in the spreading settlements south of the inland highway and the railway line. On the other hand,

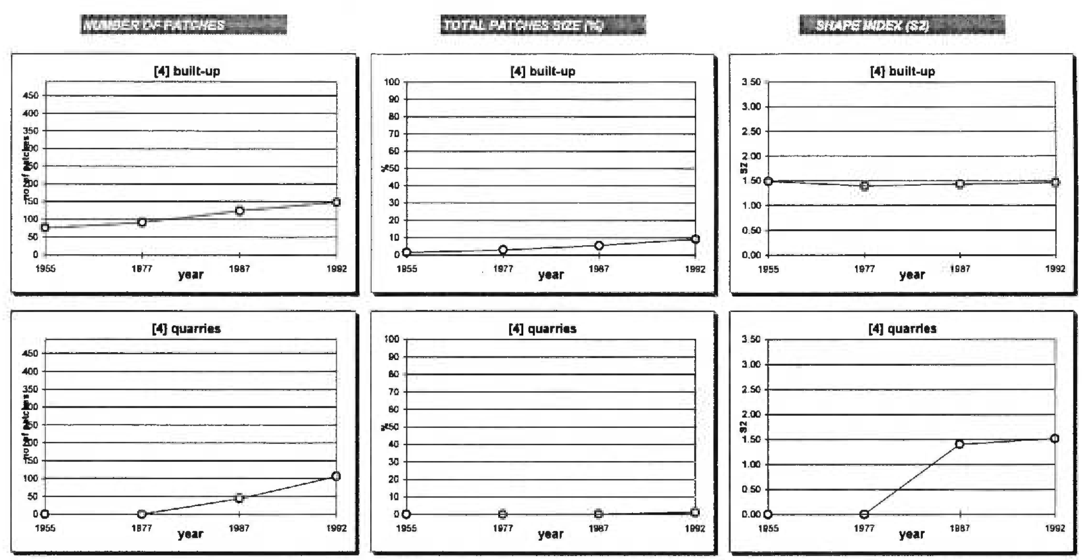


Figure 5.15: The change in the ecological characteristics of the built-up areas in the fourth sector (the non-saline depression).

the area of the quarries and the construction sites did not change dramatically; between 1955 and 1992 it attained an increase of only 1.07%.

b. Visual characteristics

This region tended to be more diversified as more patches from different classes were introduced, and as the process of fragmentation of the background matrix increased. Other diversity classes tended to decrease throughout the period under investigation. On the other hand, the activity classes of semi-natural/natural combination decreased dramatically from 47.04% in 1955 to 13.49% in 1992 (Figure 5.16). Otherwise, artificial, artificial/natural combinations and equal-shared areas gradually increased. The natural areas

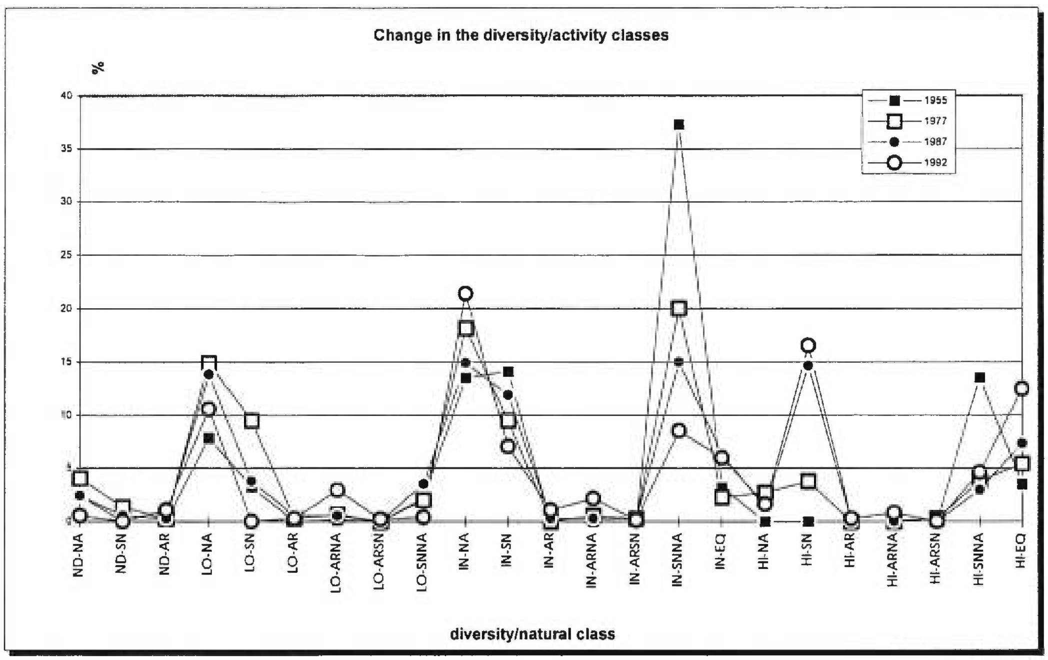


Figure 5.16: The change in the visual characteristics of the fourth sector (the non-saline depression).

increased to 34.14% in 1992, although their area fluctuated during the period of study.

This trend may be explained by the notable increase in the classes of the natural area of salt marsh vegetation and the diversification of the agricultural land. Fragmented patches of natural and agricultural origins increased the diversity index and the activity rates.

The transition matrix of the land use diversity (Table 5-8) shows a 4.54 increase in the higher diversity which was mainly gained from intermediate and

Table 5-8: Transition matrix of the percent change in land use diversity between 1955 and 1992 in the fourth sector (the non-saline depression). (0) no diversity, (1) low, (2) intermediate, and (3) high diversity

1955 \ 1992	0	1	2	3	total
0	11.85	8.36	13.66	2.11	35.98
1	7.75	5.74	9.17	1.71	24.37
2	11.90	8.45	13.90	2.97	37.23
3	0.76	0.65	0.85	0.16	2.42
total	32.26	23.20	37.59	6.96	100.00

no-diversity areas. It was also notable that this sector witnessed remarkable changes in its degree of naturalness (Table 59). The artificial classes increased from 0.68% in 1955 to 7.43% in 1992; this was due to major transformation from natural and semi-natural classes. The semi-natural classes also decreased in favor of the natural areas which gained 17.67% of this change. A 9.75% decrease in the natural/semi-natural combination was also witnessed in this sector.

Table 5-9: Transition matrix of the percent change in the degree of naturalness between 1955 and 1992 in the fourth sector (the non-saline depression).(1) artificial, (2) semi-natural, (3) natural, (12) artificial/semi-natural, (13) artificial/natural, (23) semi-natural/natural, and (123) equal share.

1955 \ 1992	1	2	3	12	13	23	123	total
1	0.44	0.01	0.17	0.01	0.03	0.01	0.00	0.68
2	1.85	15.67	17.67	0.15	0.58	3.45	0.74	40.10
3	3.68	8.92	19.83	0.17	1.87	3.56	0.82	38.85
12	0.11	0.02	0.00	0.00	0.02	0.00	0.01	0.17
13	0.20	0.03	0.19	0.00	0.00	0.02	0.02	0.48
23	0.83	6.05	8.98	0.10	0.37	1.89	0.51	18.72
123	0.32	0.18	0.39	0.03	0.01	0.03	0.03	1.00
total	7.43	30.89	47.23	0.46	2.89	8.97	2.13	100.00

5.1.5.The fifth sector: Sokkarah ridge and the Inland Plateau

a. *Ecological characteristics*

- ***The natural areas***

The only natural class existing in this region is the background matrix (bare soil and natural vegetation) which increased from 73.3% to 90.15% in the period between 1955 and 1977 (Figure 5.17). Even the number of patches decreased from 32 to only 4 in 1977 which demonstrates a general increase in

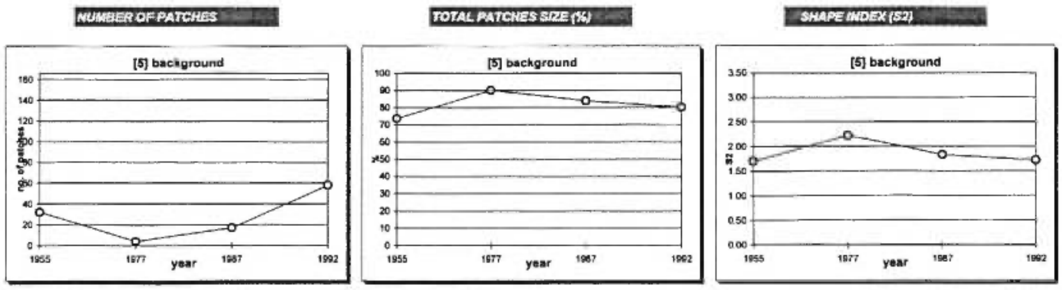


Figure 5.17: The change in the ecological characteristics of the classes of the natural area in the fifth sector (Sokkarah ridge and the inland plateau).

the connectivity level. However, this situation did not last for a long time. The total area gradually decreased to 80.19% in 1992 and the fragmentation and dissection processes increased, which was clearly reflected in the greater numbers of patches with an associated decrease in the corresponding shape index.

- ***The agricultural land***

There was a notable decrease in the total area of agricultural land in this region. The area of crop-cultivated land dropped from 11.72% in 1955 to only 0.04% in 1992 (Figure 5.18). A sudden decrease was recorded between 1955 and 1977; this was associated with a decrease in both the number of patches and the shape index. Even the ploughed fields were almost disappearing in 1992.

It is notable that till 1992, the main trend in this region was disoriented to the more fertile land on the ridge north of Sokkarah (the fourth sector). New projects of El-Nasr canal were introduced to the south of this region. These projects may change the pattern of the agricultural practices in the whole study area in the following decades.

- ***The built-up areas***

The built environment in this region is almost negligible as it varied from 0.38% to 0.03% throughout the period under investigation (Figure 5.19).

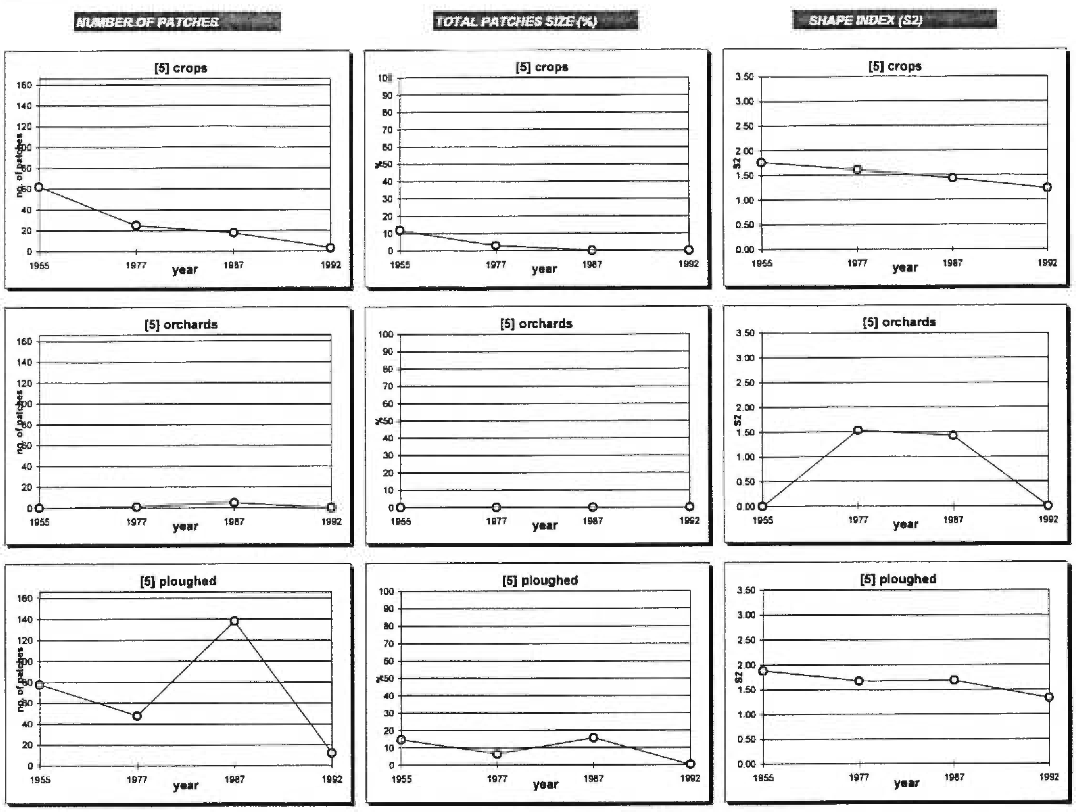


Figure 5.18: The change in the ecological characteristics of the classes of the agricultural land in the fifth sector (Sokkarah ridge and the inland plateau).

What is striking is the notable increase of the quarries and the construction sites. The major irrigation project of El-Nasr canal was detected only in 1992. This project, till present, is causing lots of destruction to the surrounding land, and achieved more than 1.5 km in width in some places. Another quarry site of about 1 km^2 in diameter is clearly detected to the east of this project.

b. *Visual characteristics*

A general change in the visual characteristics of this sector was expected due to the total loss of the agricultural land and its substitution with the quarries, the construction sites and the canal project. This caused an increase in the low and no diversity areas and a decrease in the higher diversity areas

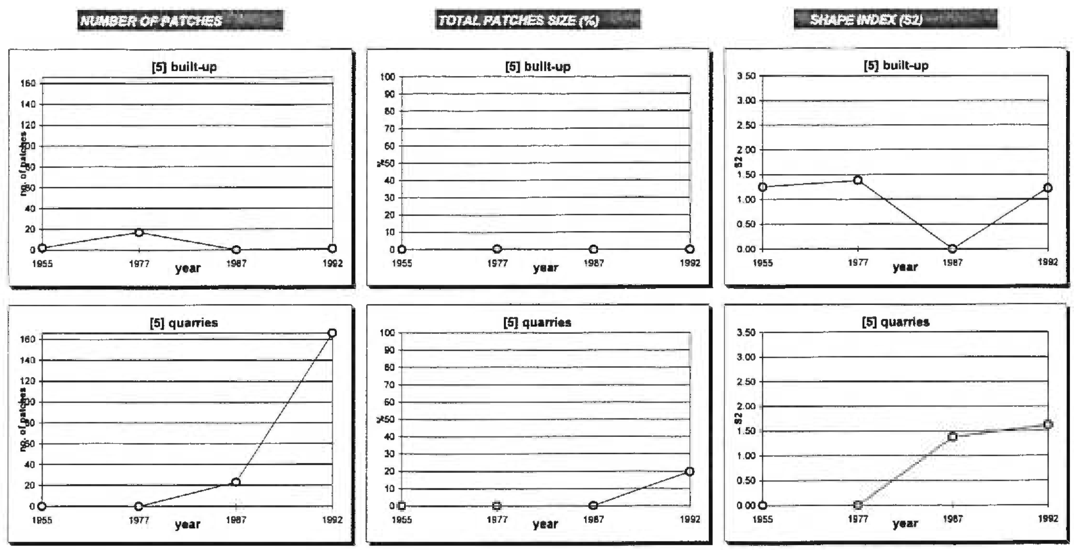


Figure 5.19: The change in the ecological characteristics of the classes of the built-up areas in fifth sector (Sokkarah ridge and the inland plateau).

(Figure 5.20). This region, considered for future agricultural development, and subsequent urbanization, should be given a special attention in managing its visual resources.

The transition from no-diversity to low and intermediate diversity is depicted in Table 5-10. This increased from 57.4% to 63.52% gaining 11.85% from low classes, and 14.40% from the intermediate diversity area. However, the intermediate diversity classes decreased by 5.15% from 1955 to 1992. 3.4% of these remained unchanged, while 10.47% was transformed to no-diversity, and 3.28% to low diversity. On the other hand, the artificial areas increased from zero percent in 1955 to 11.94% in 1992 (Table 5-11). This was transformed from natural areas (10.08%) and from semi-natural/natural classes. A loss of 17.18% of the semi-natural classes was also detected in favor of the increase of the natural areas (15.96 increase). This depicts the transformation of the agricultural land to natural areas. A 9.31% increase in the artificial/natural areas is also notable, 6.77% of which was transformed from natural classes.

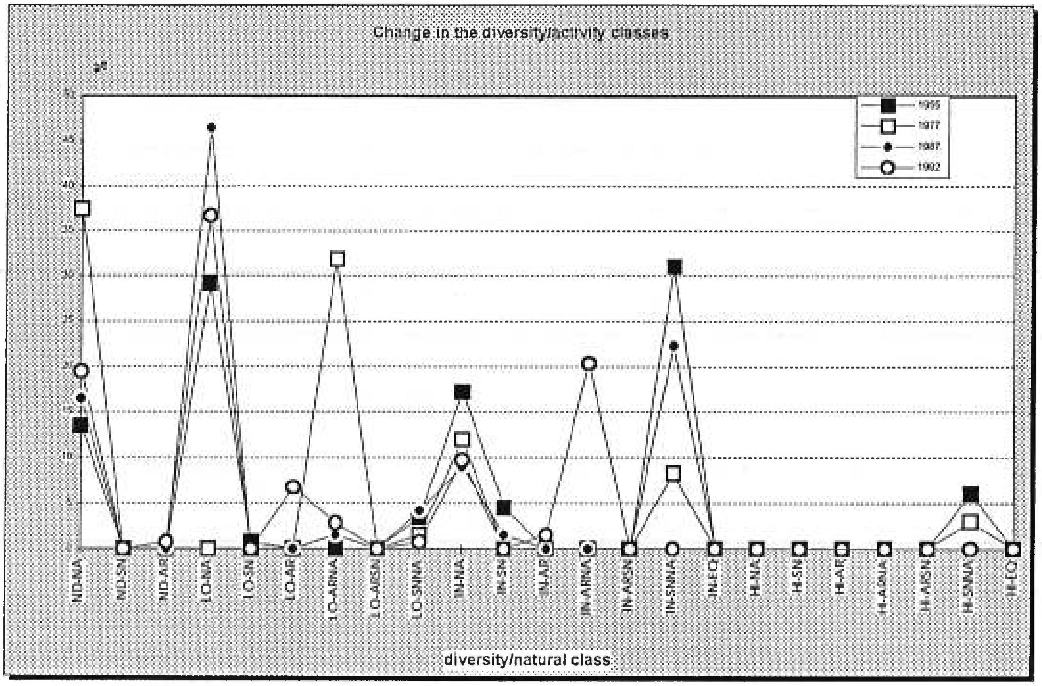


Figure 5.20: The change in the visual characteristics of the fifth sector (Sokkarah ridge and the inland plateau).

5.1.6. The socioeconomic attributes

As previously mentioned, the acquired socioeconomic information of the region is in the form of demographic data of population distribution and their economic activities for 1960, 1976 and 1986 respectively. The socioeconomic data cover the total area of El-Hammam and Burg El-Arab villages and their suburbs; these were considered as the main study units because of the lack of a clear and mapped definition of urban and suburban sectors and boundaries for the region's census data.

Generally, the total population increased from 11,706 in 1960 to 36,618 inhabitants in 1986 with an almost stable growth rate of 6.02% per year between 1960 and 1976 and of 5.93% per year between 1976 and 1986. Furthermore, the presentation of the change in the population distribution (Figure 5.21) depicts a notable increase in inhabitants of 10 years and younger. Despite the more or less

Table 5-10: Transition matrix of the percent change in land use diversity between 1955 and 1992 in the fifth sector (the inland plateau). (0) no diversity, (1) low, (2) intermediate, and (3) high diversity

1955 \ 1992	0	1	2	3	total
0	36.75	10.17	10.47	0.00	57.40
1	11.85	4.32	3.28	0.00	19.45
2	14.40	4.62	3.40	0.00	22.42
3	0.52	0.09	0.12	0.00	0.74
total	63.52	19.20	17.27	0.00	100.00

Table 5-11: Transition matrix of the percent change in the degree of naturalness between 1955 and 1992 in the fifth sector (the inland plateau).(1) artificial, (2) semi-natural, (3) natural, (12) artificial/semi-natural, (13) artificial/natural, (23) semi-natural/natural, and (123) equal share.

1955 \ 1992	1	2	3	12	13	23	123	total
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	2.33	15.96	0.00	1.13	0.09	0.00	19.51
3	10.08	0.00	51.09	0.00	6.77	0.03	0.00	67.96
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03
23	1.87	0.00	9.16	0.00	1.44	0.03	0.00	12.50
123	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	11.94	2.33	76.23	0.00	9.34	0.15	0.00	100.00

stability of the annual growth rate from the sixties till 1986, the corresponding growth rate of ages of 10 years and younger increased from 5.97% per year between 1960 and 1976 to 6.83% per year between 1976 and 1986. It is assumed that if such rates remained relatively unchanged, the total population of the study area will be 67377 inhabitants by the year 2000, from which 51.42% are of 10 years old and younger (about 34644 inhabitants). Table 5-12 summarizes the total population and the change rates between different years under investigation and the projected figure for the year 2000.

On the other hand, the economic activities presented in Table 5-13, Table 5-14, and Table 5-15 summarize the changes that have occurred during the period

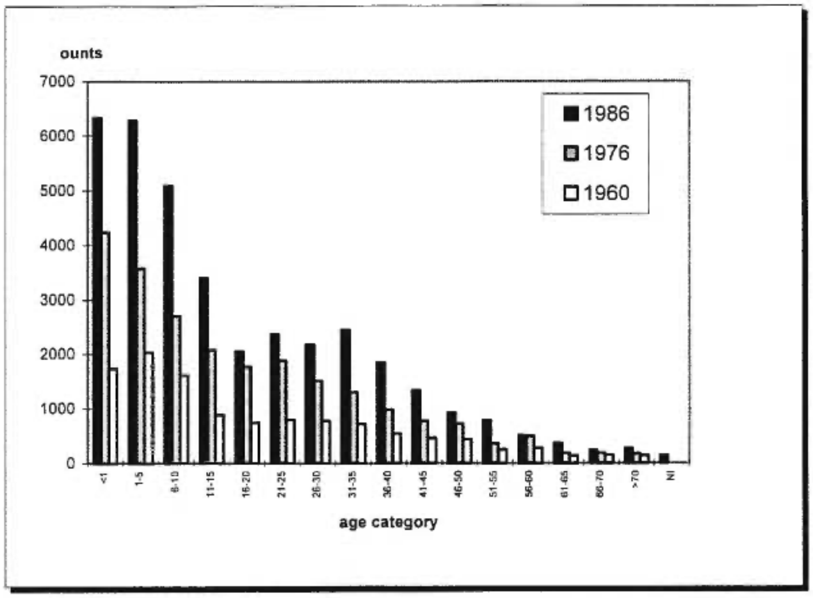


Figure 5.21: The change in the population distribution between 1960 and 1986.

Table 5-12: Total population distribution and projected estimation for the year 2000.

	1960		1976		1986	2000
total population	11706		22986		36618	67377
growth rate (% per year)		6.02		5.93		
pop. of 10 years and <	5381		10524		17710	34644
% from total population	45.97		45.78		48.36	51.42
growth rate (% per year)		5.97		6.83		

under investigation. First, a notable decrease in the total percentage of the total numbers of the working population is perceived. This percentage increased from 25.35% in 1960, to 30.03% in 1976, but it decreased by 6.13% in 1986 although the percentage of women participation increased from 2.36% in 1960 to 5.31% in 1986. The notable decrease in the percentage of agriculture workers dropped from 70.71% in 1960 to 41.61% in 1986, a loss of about 29.1% of the total working population. This was associated with a corresponding increase in quarries, transport, and social services (Figure 5.22).

Table 5-13: The distribution of the economic activities in 1986

total population for 1986 is 36618							1986								
NUMBERS	AGRICULTURE	%	QUARRIES	%	INDUST-CONST	%	TOURISM	%	TRANSPORT	%	SOCIAL SERV	%	OTHERS	%	TOTAL
M	3561	9.7%	885	2.4%	1042	2.8%	729	2.0%	465	1.3%	943	2.6%	662	1.8%	
F	81	0.2%	15	0.0%	32	0.1%	50	0.1%	11	0.0%	200	0.5%	76	0.2%	
TOTAL	3642	9.9%	900	2.5%	1074	2.9%	779	2.1%	476	1.3%	1143	3.1%	738	2.0%	8752
PERCENTAGE OF WORKING POPULATION (FROM TOTAL POPULATION OF 1986 (36618))															23.90 %
PERCENTAGES FROM TOTAL WORKING POPULATION (8752)															
M	40.69		10.11		11.91		8.33		5.31		10.77		7.56		94.69 %
F	0.93		0.17		0.37		0.57		0.13		2.29		0.87		5.31 %
TOTAL	41.61		10.28		12.27		8.90		5.44		13.06		8.43		100.00

Table 5-14: The distribution of the economic activities in 1976

total population for 1976 is 22986							1976								
NUMBERS	AGRICULTURE	%	QUARRIES	%	INDUST-CONST	%	TOURISM	%	TRANSPORT	%	SOCIAL SERV	%	OTHERS	%	TOTAL
M	4194	18.2%	64	0.3%	976	4.2%	671	2.9%	301	1.3%	397	1.7%	148	0.6%	
F	72	0.3%	0	0.0%	11	0.0%	10	0.0%	0	0.0%	53	0.2%	6	0.0%	
TOTAL	4266	18.6%	64	0.3%	987	4.3%	681	3.0%	301	1.3%	450	2.0%	154	0.7%	6903
PERCENTAGE OF WORKING POPULATION (FROM TOTAL POPULATION OF 1976 (22986))															30.03 %
PERCENTAGES FROM TOTAL WORKING POPULATION (6903)															
M	60.76		0.93		14.14		9.72		4.36		5.75		2.14		97.80 %
F	1.04		0.00		0.16		0.14		0.00		0.77		0.09		2.20 %
TOTAL	61.80		0.93		14.30		9.87		4.36		6.52		2.23		100.00

Table 5-15: The distribution of the economic activities in 1960

total population for 1960 IS 11706							1960								
NUMBERS	AGRICULTURE	%	QUARRIES	%	INDUST-CONST	%	TOURISM	%	TRANSPORT	%	SOCIAL SERV.	%	OTHERS	%	TOTAL
M	2061	17.6%	1	0.0%	217	1.9%	257	2.2%	80	0.7%	118	1.0%	163	1.4%	
F	37	0.3%	0	0.0%	10	0.1%	7	0.1%	1	0.0%	7	0.1%	8	0.1%	
TOTAL	2098	17.9%	1	0.0%	227	1.9%	264	2.3%	81	0.7%	125	1.1%	171	1.5%	2967
PERCENTAGE OF WORKING POPULATION (FROM TOTAL POPULATION OF 1960 (11706))															25.35 %
PERCENTAGES FROM TOTAL WORKING POPULATION (2967)															
M	69.46		0.03		7.31		8.66		2.70		3.98		5.49		97.64 %
F	1.25		0.00		0.34		0.24		0.03		0.24		0.27		2.35 %
TOTAL	70.71		0.03		7.65		8.90		2.73		4.21		5.76		100.00

5.2. Analysis of the variations and interrelationships between landscape attributes

The aim of this analysis is to assess the variations and the degree of association between landscape attributes. Two types of assessment were carried-out: (a) assessment of the significance of variations in landscape attributes by the Analysis of Variance (ANOVA)), in order to evaluate the variations in each attribute with time and habitat, and (b) the assessment of the relationships between these attributes by the correlation coefficient which evaluates the interrelated variations of these attributes.

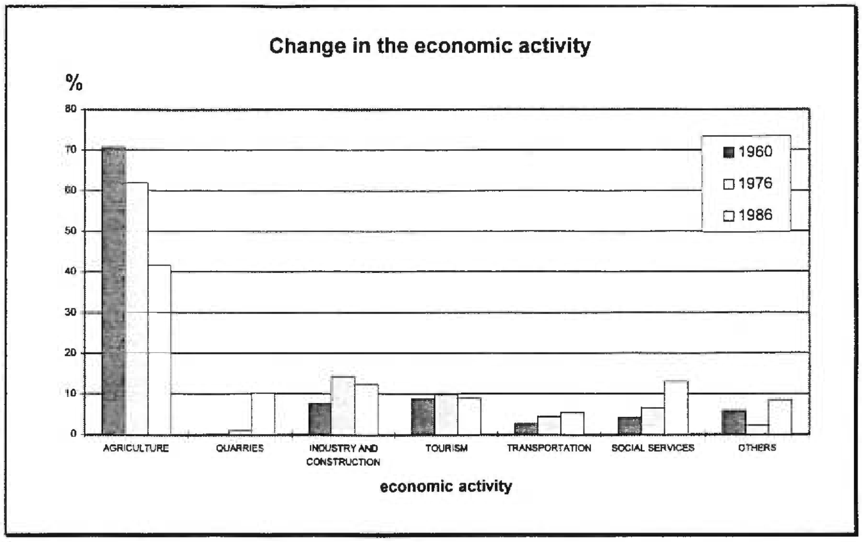


Figure 5.22: the changes in the economic activities for the study area

The objective of the latter is to depict the relationship between these attributes by arranging them in a multi-dimensional ordination space based on the values of mutual similarities (correlations). In simple terms, ordination is a procedure for adapting a multidimensional swarm of data points in such a way that when projected onto a two space, any intrinsic pattern the swarm may possess becomes apparent. Principal Component Analysis (PCA) is one of the simplest of all ordination methods, where the swarm of data is projected as it stands (without any weighting) onto a differently oriented space. Each of the axes of the original coordinate frame in which the data points are plotted is rotated rigidly around its origin in such a way that, relative to the new axes, the pattern of the data swarm shall be as simple as possible. PCA technique can be applied to all data which satisfy the following basic requirements: (Pielou, 1984):

1. For each of a number of individual sampling units, the same variables are measured and recorded. All the measurements must be made on each individual.

2. The variables selected for analysis are assumed to be continuous. It is possible that the analysis can be extended to deal with qualitative attributes which are scaled or scored.

The objective of a PCA may include one or more of the following (Jeffers, 1978):

1. Examination of the correlation between separate variables.
2. Reduction of the basic dimension of the variability to the smallest numbers of meaningful dimensions.
3. Examination of the most informative groupings of the individual sampling units.
4. Determination of the objective weighting of the variable.

The PCA functions in such a way that, given N separate axes (variables), the correlations between them are analyzed, and a set is obtained of N new axes which are un-correlated. Subject to some constraints, the first PC should contain the information which is common to all the original axes. The second PC should show the most significant variable in all original variables (which is much less significant than the common information). Successive PC axes should show successively less significant variables up to the (N-1)th, and the Nth PC axis contains whatever information is left over.

PCA works on a variety of statistical parameters: (1) the mean and standard deviation; these provide a general inference on the overall average and variation of values; (2) a correlation coefficient matrix, which shows if the variables are either positively or negatively correlated; (3) a covariance matrix, when related to two appropriate variances of two different variables gives a measure of how much contrast is common in these two variables.

PCA involves the extraction of the eigenvalues and eigenvectors of the matrix of correlation coefficients of the original variables. The resulting eigenvalues and eigenvectors define the components of the total variability described by the original variables as linear functions of these variables.

Finally a clustering analysis is applied in order to detect which change in the group or groups of variables is associated with the change in others. The clustering analysis is a multivariate descriptive model, used when all inputs are quantitative. The database used consists of a sample of units each described by a series of selected variables. The objective is to group either the data units or variables into clusters so that the elements within a cluster have a high degree of "natural association" among themselves, while the clusters are "relatively distinct" from one another. Cluster analysis assumes that little or nothing is known about the structure which underlines a data set. The essence of cluster analysis might be viewed as that of assigning appropriate meaning to the terms "natural groups" and "natural association".

5.2.1.Assessment of the significance of variations in landscape attributes

The analysis of variance (ANOVA) was applied in the present study on the records expressing the variations in ecological, visual and socioeconomic attributes (variables) of the years 1955, 1977, 1987 and 1992. These records were normalized by transforming them to the square root prior to the analysis. The objective of this analysis is to assess the significance of variations in these attributes with time (year), as well as with habitat in the case of the three ecological attributes. Since the visual attributes were recorded for each sector of the study area as a whole, habitat could not be considered as a factor beside time (year) in the analysis of variance. In case of the social attributes which were recorded for the study area as a whole (not for each sector and habitat), the first three of these attributes (expressing variations in age classes), male and female records were used as replicas, while in the case of the remaining social attributes there were no replicas to use in the analysis of variance. This means that the analysis was carried out on 17 variables: 3 ecological, 11 visual (4 diversity and 7 activity), and 3 social (age). The results of the analysis are summarized in Table 5-16. It is obvious that patch number and patch shape varied significantly (probability that their variation is random is less than 0.05) with year, and that these two variables as well as the patch size varied highly significantly ($P<0.01$) with habitat. On the other hand, the variation in this latter variable with time was not significant ($P>0.05$).

Table 5-16: F and P- values resulting from the analysis of variance (ANOVA) of the ecological, visual and social attributes recorded for the study area in 1955, 1977, 1987 and 1992

Source of Variation	*F*	*P*
1-ECOLOGICAL / PATCH NUMBER		
Year	3.07	0.03
Habitat	7.51	<0.001
Interaction	1.53	0.07
2-ECOLOGICAL / PATCH SIZE		
Year	2.80	0.04
Habitat	5.23	<0.001
Interaction	2.69	<0.001
3-ECOLOGICAL / PATCH SHAPE		
Year	0.09	0.97
Habitat	17.00	<0.001
Interaction	0.99	0.48
4-VISUAL DIVERSITY-0		
Year	11.35	<0.001
5-VISUAL DIVERSITY-1		
Year	2.88	0.04
6-VISUAL DIVERSITY-2		
Year	4.09	0.01
7-VISUAL DIVERSITY-3		
Year	1.67	0.18
8-VISUAL ACTIVITY-1		
Year	124.65	<0.001
9-VISUAL ACTIVITY-2		
Year	0.93	0.43
10-VISUAL ACTIVITY-3		
Year	2.75	0.04
11-VISUAL ACTIVITY-4		
Year	3.18	0.03
12-VISUAL ACTIVITY-5		
Year	41.90	<0.001
13-VISUAL ACTIVITY-6		
Year	43.94	<0.001
14-VISUAL ACTIVITY-7		
Year	2.78	0.04
15-SOCIAL DEMOGRAPHY (AGE<10)		
Year	1305.07	<0.001
16-SOCIAL DEMOGRAPHY (AGE<11-55)		
Year	286.43	<0.001
17-SOCIAL DEMOGRAPHY (AGE>55)		
Year	2.04	0.25

This significance of variations in patch size, shape and number with habitat expresses the notable heterogeneity in habitat features in the study area, which controls the type and pattern of land use activities, and is reflected in such variations in patch characteristics. Land use type and intensity has obviously been changing from year to year at an accelerated rate, which is again reflected in the significant variations in patch number and shape.

Variations with time (year) in the visual attributes, except the attributes "intermediate-diversity" and "semi-natural-activity" were all significant or highly significant. This again reflects the strong impact of the changing land use and land cover on the visual attributes of the landscape in the study region. The high rate of change in the demographic (social) attributes is strongly expressed by the highly significant variations with time in the age class of <10 years and the age class of 11-55 years, such change which is almost missing in the older age class of >55 years. This trend of demographic change indicates the high potentiality of population increase, and may be expected to have a far reaching impact on landscape attributes in the study area in the future.

5.2.2. The relationship between landscape attributes: Multivariate analysis

a. *The principal component analysis (PCA)*

An ordination technique was applied in the present study on the records expressing variations in the 34 ecological, visual and social attributes in the years 1955, 1977, 1987 and 1992 (Table 4-7). These records were normalized by transforming them to the square roots prior to the analysis.

The eigenvalues extracted from PCA applied to the records of the present study (Table 5-17) indicate that the first three ordination axes, (PC1, PC2 and PC3) account for about 50%, 15% and 9% (with a cumulative percentage of 74%) of the total variance respectively of all attributes (variables).

The loadings of variables on PC1 as estimated from the eigenvector matrix indicate the amount of information derived from each of the 34

Table 5-17: Cumulative percent of eigen values of the first thirteen principal component axes

AXES	EIGENVALUE	PERCENT	CUMULATIVE
1	10.52671	50.26	50.26
2	3.12063	14.90	65.16
3	1.91989	9.17	74.33
4	1.79106	8.55	82.88
5	1.14890	5.49	88.36
6	0.61775	2.95	91.31
7	0.54117	2.58	93.90
8	0.37482	1.79	95.69
9	0.30535	1.46	97.15
10	0.22488	1.07	98.22
11	0.15643	0.75	98.97
12	0.11493	0.55	99.51
13	0.07970	0.38	99.89

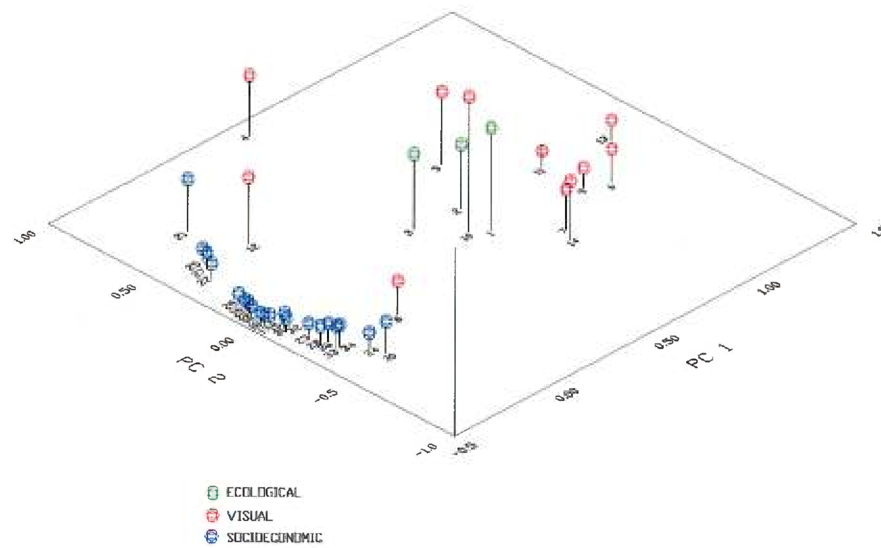
landscape attributes (variables) and expressed on PC1 axis (Table 5-18). By categorizing the 34 variables into three categories, ecological, visual and social variables, PC1 axis expressed about 58% of the visual variables (variables 4-14), mainly variables 6 (intermediate-diversity), 9 (semi-natural-activity) and 13 (natural/semi-natural-activity), (with variable 13 dominating). The loading of the social variables (15-34) on PC1 was about 34% representing an overall average of all these variables collectively. The loading of the ecological variables (1-3) on PC1 was about 8% (with variable 2 (size of patches) dominating).

Similarly, PC2 expresses about 51% of the social variables, (with variable 21 (Male/Agricultural) dominating), 43% of the visual variables (with variable 4 (no diversity) dominating), and 1% of the ecological variables. The 9% variance accounted for by PC3 axis expresses about 62% of the visual variables (with variable 10 (natural-activity) dominating), 28% of the ecological variables (with variable 3 (shape of patches) dominating), and about 9% of the social variables.

Table 5-18: Ratios of standardized (squared) eigen vectors of three principal component axes (PC1, PC2, and PC3) for each landscape attribute.

ATTRIBUTES	*PC1*	*PC2*	*PC3*
1	2.88	0.81	8.14
2	3.36	0.10	7.41
3	1.53	0.23	12.59
4	0.98	25.87	9.22
5	4.20	4.68	13.80
6	10.18	1.13	1.48
7	5.01	3.80	1.35
8	0.05	2.51	0.60
9	8.24	0.79	0.11
10	2.27	0.13	21.00
11	8.02	0.30	0.01
12	0.28	3.93	10.74
13	14.88	0.09	0.18
14	4.36	4.30	3.77
15	2.11	0.00	0.02
16	2.11	0.00	0.01
17	2.05	0.27	0.01
18	2.10	0.02	0.00
19	2.10	0.10	0.06
20	2.03	0.39	0.03
21	0.36	13.43	1.89
22	1.64	2.68	0.33
23	1.94	1.07	0.33
24	1.08	5.27	0.67
25	1.34	4.73	0.64
26	1.65	2.64	0.73
27	1.45	3.95	0.52
28	1.75	2.13	0.61
29	1.97	0.72	0.06
30	0.98	6.27	1.17
31	2.11	0.02	0.03
32	2.09	0.15	0.08
33	1.46	3.66	0.99
34	1.43	3.83	1.04

The ordination of landscape attributes , considered by the present study, along the first three principal component axes (Figure 5.23) indicates clear separation, with a few exceptions, of the three groups: ecological, visual and socioeconomic. The two types of visual attributes (i.e. diversity and activity) are also clearly separated. It is notable that ecological attributes appear in the middle, between visual and social attributes. Although these two latter groups of attributes seem to be remotely separated in the ordination space, two of the visual activity attributes, 8 (artificial) and 12 (artificial/natural)) are more closely related to some social attributes (r up to 0.71, and to 0.53 respectively) than to other visual attributes. On the other hand, another visual activity, attribute 13 (natural/semi-natural)) is negatively correlated with the group of



a=229 b=50 r=99.0

Figure 5.23: A three dimensional view of the "Principal Component" ordination of the selected ecological (1-3), visual (diversity 4-6, and activity 7-14), and socioeconomic (15-34) landscape attributes.

social attributes (r = -0.6 to -0.05), and appears remotely separated from it on the ordination plane. The most closely related visual attributes to the three ecological attributes are the attributes 7 (high visual diversity) and 14 (equal-share-visual activity).

The clumping of socioeconomic attributes away from the other two groups of attributes signifies their special nature. The matrix of correlation coefficients (Table 5-19) indicates the highest mutual coefficients between these attributes (r up to 0.99). A better separation between social attributes is obtained in the two-dimensional space of the first and second principal component axes (Figure 5.24).

Table 5-19: Matrix of correlation coefficient between the 34 ecological (1-3), visual (diversity 4-6, and activity 7-14) and socioeconomic (15-34) landscape attributes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
1	1.00																																	
2	0.66	1.00																																
3	0.50	0.49	1.00																															
4	-0.18	-0.04	-0.15	1.00																														
5	0.15	0.16	-0.04	0.45	1.00																													
6	0.38	0.28	0.06	-0.10	0.53	1.00																												
7	0.47	0.30	0.21	-0.32	0.20	0.79	1.00																											
8	0.29	0.12	0.08	-0.26	0.08	0.15	0.44	1.00																										
9	0.40	0.27	0.03	-0.13	0.55	0.91	0.78	0.26	1.00																									
10	0.18	0.15	0.11	0.15	0.49	0.46	0.33	0.18	0.26	1.00																								
11	0.31	0.22	0.01	-0.04	0.49	0.78	0.61	0.15	0.48	0.22	1.00																							
12	0.01	-0.04	-0.06	0.09	-0.17	-0.31	-0.04	0.48	-0.15	-0.59	-0.11	1.00																						
13	0.19	0.16	-0.03	-0.13	0.41	0.75	0.42	-0.36	0.75	0.07	0.68	-0.47	1.00																					
14	0.44	0.25	0.22	-0.49	0.15	0.69	0.83	0.36	0.78	0.14	0.67	-0.08	0.50	1.00																				
15	0.15	0.03	0.11	0.02	0.05	-0.20	0.09	0.68	-0.06	0.14	-0.11	0.50	-0.61	0.13	1.00																			
16	0.14	0.03	0.11	0.02	0.05	-0.20	0.09	0.67	-0.06	0.14	-0.10	0.50	-0.61	0.13	0.99	1.00																		
17	0.13	0.02	0.12	0.06	0.06	-0.22	0.07	0.65	-0.07	0.12	-0.08	0.51	-0.61	0.12	0.99	0.99	1.00																	
18	0.14	0.02	0.12	0.03	0.05	-0.21	0.08	0.67	-0.07	0.13	-0.10	0.50	-0.61	0.13	0.99	0.99	0.99	1.00																
19	0.15	0.03	0.11	-0.01	0.04	-0.19	0.09	0.69	-0.06	0.15	-0.12	0.48	-0.61	0.13	0.99	0.99	0.98	0.99	1.00															
20	0.13	0.02	0.12	0.07	0.07	-0.22	0.07	0.64	-0.07	0.11	-0.08	0.52	-0.61	0.12	0.99	0.99	0.99	0.99	0.98	1.00														
21	0.01	0.01	0.15	0.29	0.13	-0.25	-0.02	0.30	-0.10	-0.02	0.07	0.47	-0.45	0.03	0.67	0.69	0.76	0.70	0.63	0.77	1.00													
22	0.09	0.02	0.14	0.15	0.09	-0.24	0.04	0.56	-0.09	0.07	-0.03	0.53	-0.59	0.10	0.94	0.94	0.97	0.95	0.91	0.98	0.89	1.00												
23	0.17	0.03	0.09	-0.07	0.02	-0.16	0.11	0.70	-0.04	0.17	-0.15	0.44	-0.58	0.14	0.98	0.97	0.94	0.97	0.99	0.93	0.49	0.84	1.00											
24	0.23	0.06	0.13	-0.24	-0.03	-0.03	0.25	0.68	0.02	0.28	-0.10	0.24	-0.47	0.27	0.90	0.89	0.84	0.88	0.92	0.83	0.31	0.69	0.96	1.00										
25	0.07	0.02	0.14	0.19	0.10	-0.25	0.03	0.51	-0.09	0.05	-0.01	0.52	-0.56	0.08	0.89	0.90	0.94	0.91	0.86	0.94	0.94	0.99	0.77	0.61	1.00									
26	0.18	0.03	0.07	-0.12	0.00	-0.13	0.12	0.70	-0.03	0.19	-0.17	0.39	-0.55	0.15	0.93	0.93	0.88	0.92	0.95	0.87	0.36	0.75	0.99	0.98	0.66	1.00								
27	0.08	0.02	0.14	0.18	0.10	-0.25	0.03	0.53	-0.09	0.06	-0.01	0.52	-0.57	0.09	0.91	0.91	0.95	0.92	0.88	0.96	0.92	0.99	0.79	0.64	0.99	0.69	1.00							
28	0.18	0.03	0.08	-0.11	0.00	-0.14	0.12	0.70	-0.03	0.18	-0.17	0.41	-0.56	0.15	0.95	0.94	0.90	0.93	0.96	0.89	0.40	0.77	0.99	0.98	0.69	0.99	0.72	1.00						
29	0.12	0.02	0.13	0.09	0.07	-0.23	0.06	0.63	-0.08	0.11	-0.07	0.52	-0.61	0.11	0.98	0.98	0.99	0.99	0.97	0.99	0.80	0.99	0.92	0.80	0.96	0.85	0.97	0.87	1.00					
30	0.23	0.06	0.11	-0.26	-0.04	-0.03	0.25	0.68	0.04	0.31	-0.12	0.20	-0.47	0.25	0.87	0.87	0.81	0.86	0.90	0.80	0.25	0.65	0.95	0.99	0.56	0.98	0.60	0.98	0.77	1.00				
31	0.15	0.03	0.11	0.01	0.04	-0.20	0.09	0.68	-0.06	0.14	-0.11	0.49	-0.61	0.13	0.99	0.99	0.99	0.99	0.99	0.99	0.66	0.93	0.98	0.91	0.88	0.94	0.90	0.95	0.98	0.89	1.00			
32	0.15	0.03	0.10	-0.01	0.04	-0.19	0.09	0.69	-0.06	0.15	-0.12	0.48	-0.61	0.14	0.99	0.99	0.98	0.99	0.99	0.98	0.62	0.91	0.99	0.93	0.85	0.96	0.87	0.97	0.96	0.91	0.99	1.00		
33	0.18	0.03	0.06	-0.15	-0.02	-0.11	0.13	0.70	-0.02	0.19	-0.18	0.37	-0.53	0.15	0.90	0.90	0.84	0.89	0.93	0.83	0.29	0.69	0.96	0.98	0.61	0.99	0.64	0.99	0.80	0.99	0.91	0.93	1.00	
34	0.18	0.03	0.06	-0.15	-0.02	-0.11	0.13	0.69	-0.02	0.19	-0.18	0.36	-0.52	0.15	0.90	0.89	0.84	0.88	0.92	0.83	0.28	0.69	0.97	0.98	0.60	0.99	0.63	0.99	0.80	0.99	0.91	0.93	0.99	1.00

b. Clustering analysis

Cluster analysis is an attempt to group sample points in multidimensional space into separate sets which will correspond to observed

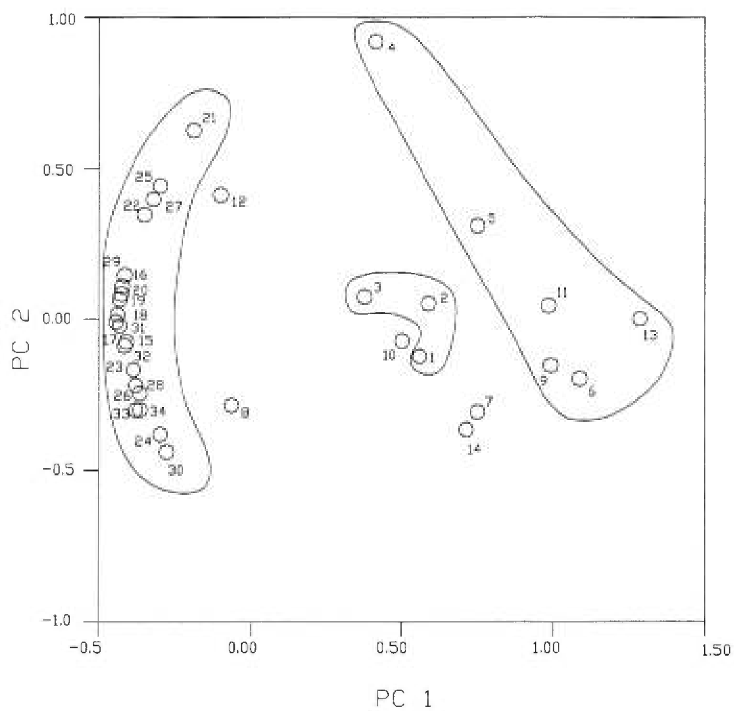


Figure 5.24: A two dimensional view (first and second axes) of the "Principal Component" ordination of the selected ecological (1-3), visual (diversity 4-6, and activity 7-14), and socioeconomic (15-34) landscape attributes. The continuous lines separate the three groups of landscape attributes

features of the sample. The group of points may themselves be grouped into larger sets, so that all the points may themselves be grouped into larger sets, and that all the points are eventually classified hierarchically. This hierarchical classification can be represented diagrammatically and it is usual to incorporate a scale into such a diagram to indicate the degree of similarity to the various groups (Figure 5.25).

From the dendrogram (graphic representation) of the clustering analysis applied to the records of the 34 landscape attributes (variables) of the present study (Figure 5.25), it is clear that the 3 ecological attributes are clustered at a similarity index of about 0.5. The visual attributes 4-14 are

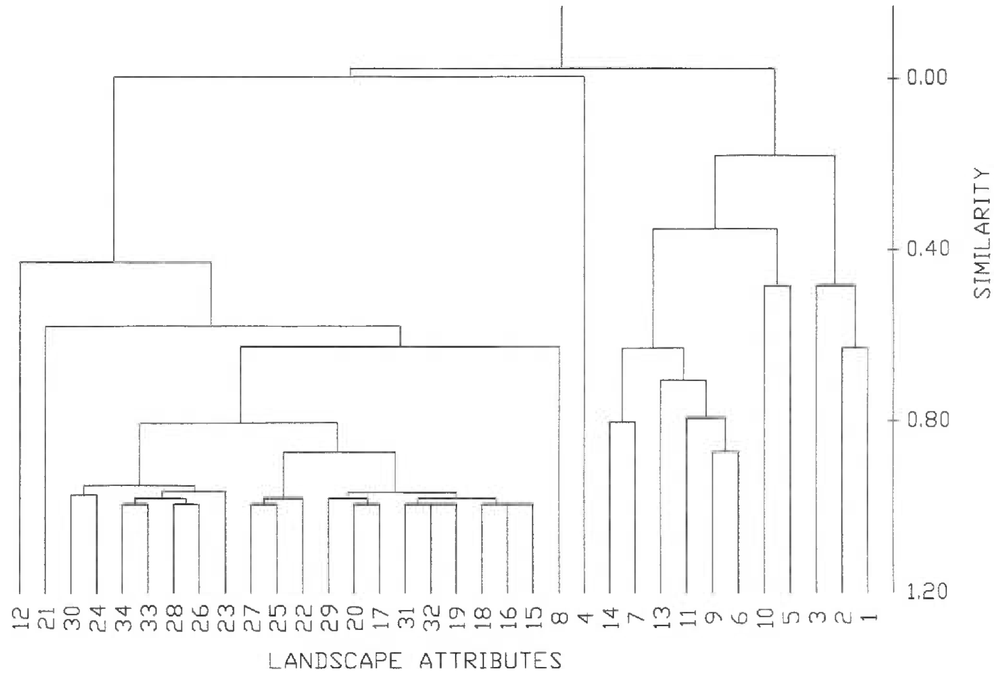


Figure 5.25: The dendrogram resulting from the cluster analysis of the landscape attributes (ecological (1-3); visual (4-14); and socioeconomic (15-34))

clustered together at a similarity index of about 0.3, except the attributes 4 (visual-no-diversity), 8 (visual-artificial-activity) and 12 (visual-artificial/natural activity). Attribute 8 (visual-artificial-activity) is the only visual attribute which exhibits higher similarity to the social attributes (15-34), and is clustered with them at a similarity index of about 0.6. This new cluster is then clustered with the visual attribute 12 (visual-artificial/natural activity) at a relatively lower similarity (0.5). The visual attribute 4 (visual-no-diversity) clusters with the latter group at a much lower level of similarity (<0.01).

The two multivariate analyses (Principal Component Ordination, and clustering) were applied in the present study, using a "Multivariate Statistical Package"[1].

[1] NTSYS, version 1.50, © Applied Biostatistics Inc., 1989.

CHAPTER VI: DISCUSSION

Few landscape studies were carried out in the western Mediterranean region of Egypt. These studies (Salem, 1989; Kamal, 1988) were concerned mainly with the classification and change detection of land use/land cover; the more recent study by Ayad (1996) introduced the application of the concept of "carrying capacity". However, there is a general consensus at present to adopt the approaches of landscape historical analysis employing spatial indices designed to quantify, for example, the number, size and shape of patches, the arrangement of landscape elements (Forman and Godron, 1986; O'Neill *et al*, 1988), and the rate and direction of landscape change (Turner, 1987). An understanding of changes in these attributes, as well as visual and socioeconomic attributes may offer significant opportunities for planners to evaluate landscape patches not only by their present resources but also according to their historical evolution, in order to enhance biodiversity and environmental quality within current land management policies and programs (Kienast, 1993; Simpson *et al*, 1994). Such understanding will also help in developing simulation models that may be utilized in predicting changes in landscape under alternative planning strategies. The present study is an attempt to integrate the previous studies carried out in the region and to fill the information gaps related to landscape attributes.

6.1. Landscape attributes

If the changes in the landscape attributes (ecological and visual) were reviewed in the different sectors of the pilot study area, it becomes evident that the rate of change in these attributes differed notably from one sector to the other. Accordingly, these sectors may be differentiated into three groups according to the amount of change that have occurred in each from 1955 till 1992. The first group includes the coastal sector (sand dunes, first depression and Abu Sir ridge), and the non-saline depression sector in which the change was remarkable. The second group includes the Mariut ridge sector and the inland plateau sector in which the changes were moderate. The third group includes only the saline depression sector in which the changes were minor.

6.1.1. The coastal sector and the non-saline depression

The change in the ecological attributes (number, size and shape of patches) was most pronounced in the sand dunes and Abu Sir ridge in the first sector, and in the non-saline depression (fourth sector) of the first group.

The process of change in landscape patches is described by Forman (1996):

> *"Land is transformed by several spatial processes overlapping in order, including perforation, fragmentation, and attrition, which increase habitat loss and isolation ... "*

He further explains:

> *"The perforation is the process of making holes in an object such as a habitat of land type (e.g., dispersed houses in a larger patch of natural vegetation). Dissection is the carving up or subdividing of an area using equal -width lines (e.g., roads or power lines). Fragmentation is the breaking of an object into pieces (that are often widely and evenly separated). Shrinkage is the decrease in size of objects, and finally, attrition is their disappearance. These five spatial processes overlap through the period of land transformation... These spatial processes all increase habitat loss and isolation. Average size decreases in the first four processes, and typically increases upon attrition, because small patches are most likely to disappear. Connectivity across an area in continuous corridors or matrix typically decreases with dissection and fragmentation".*

This description applies to the landscape units of the above-mentioned sectors. The process of fragmentation in the first sector of the first group was so pronounced on the sand dunes and the background landscape unit which represent the natural vegetation to the extent that this process led to attrition of many locations on the sand dunes and severe perforation and fragmentation in many locations in the background landscape unit.

Similarly, the change of the landscape patches of the background land cover (natural vegetation and bare soil) as well as the cultivated landscape units in the non-saline depression suffered increase in fragmentation starting 1977 till 1992. This general phenomenon of fragmentation and attrition of the landscape units of natural vegetation and cultivated land could have serious impact on the productivity of the rangeland, and consequently the secondary productivity of grazing animals as well as the productivity of the agricultural newly-reclaimed land (decrease of the total area allocated for agriculture from 49.4% in 1955 to 35.8% in 1992). This seems to be contradictory to the major objective of the Egyptian National Plan to increase the agricultural land. Conceivably, the general trend here is from extensive "vernacular" rain-fed agriculture to intensive mechanized Nile-water-irrigated agriculture. The former type depends on utilizing the natural resources of the region (e.g., harvesting of rain water in areas of soil accumulation) with minimum inputs and manipulations (e.g., shallow ploughing) in widely distributed locations in almost all sectors. The main crops are of species which have been acclimatized to the local environment for many decades. On the other hand, the latter type of agriculture depends on heavy inputs of water and nutrients imported from the Nile valley, and is restricted to only one sector where irrigation water is made available. Crops new to the region are introduced which need, for their maintenance, more elaborate agricultural and irrigation practices. With the shrinking of the extensive areas of traditional rain-fed agriculture and the encroachment of other types of land use there became accordingly a general trend of decrease in agricultural activities by local inhabitants (from 70.7% in 1960 to 41.6% in 1980). Other factors played a role in augmenting this trend: the lack of respect of the new agricultural policy in the region to the Bedouin traditional lifestyle, the high income which many local inhabitants gained from selling their agricultural land for quarrying and for construction of touristic and holiday-making villages (which is reflected in the increase of the total number of inhabitants working in quarries from 0.03% in 1960 to 10.3% in 1980), and the increase in job opportunities created by new land uses. Another cause of shrinkage of agricultural land in the study region is soil degradation (mainly salinization and water logging), which can be clearly noticed in the increase of the flooded areas and the classes of salt-marsh vegetation in this sector (from its absence in 1955 to 12.3% in 1992). This could be attributed to the application of faulty irrigation practices (canal irrigation systems) introduced to the region from the totally different environment of the Nile valley (this would heavily depend on the seasonal variations between the analyzed images), instead of innovative technologies (drip or sprinkler irrigation) which could be more practicable in the desert environment, and which have been applied successfully in agricultural projects in other desert areas of Egypt.

The present study indicates that the shape index reflects major changes in the complexity of edge to area conditions in the first group of sectors (the first sector including the sand dunes, first depression, and the Abur Sir ridge, and the fourth sector including the non-saline depression). It decreased notably for the sand dunes and the background landscape units, which indicated a transformation from vernacular and traditional practices to mechanized and extensive man-made patterns of land use.

The change in the shape index was also remarkable in the sand dunes in the first sector and in the non-saline depression (the fourth sector) of this group. In the first sector (which includes the sand dunes, the first depression and the first rocky ridge) the shape index reflects the change that have occurred to the sand dunes in the past decades, that is the transition from natural to man-made patches used for construction of touristic and holiday-making villages on the coast. During the fifties, there were no activities except some orchard plantations on the coastal dunes which followed, more or less, irregular shapes. This was reflected in relatively high values of the shape index (nearly 5). In consecutive years, the activities of holiday-making took place, which resulted in the dissection and fragmentation of the patches of the sand dunes, and the shape index dropped to minimum values (less than 2) reflecting the resulting artificial, nearly geometric construction polygons.

Rust and Illenberger (1996) noted that there is a general perception that all coastal dunes are highly sensitive to a number of impacts. Coastal dune systems are considered to be highly sensitive and inviolate. Dune systems of the study region are relatively active, that is, systems characterized by dynamic sand movement and morphological change are extremely fragile and sensitive to even low-level impacts. We have to recognize that a sensible environmental management strategy for coastal dune systems must encompass a wide spectrum of procedures (McGwyme and McLachlan, 1992). The effects of change to dune systems (some will say *damage*, not *change*) will last for periods ranging between very short (hours to days) and very long (decades and longer). Those dune systems and dune sub-environments that retain effects of change for the longest time will be viewed as 'most sensitive', and those impacts that lead to long-term change will be considered 'most damaging'. This latter case applies to the effects imposed by touristic villages in the study region.

Similarly, in the fourth sector (the non-saline depression) the shape index reflected clearly the change between the traditional rain-fed and the irrigated types of agriculture. During the fifties, dominated by rain-fed agriculture, the land use was governed mainly by natural attributes of landform boundaries and contours, resulting into a pattern of irregular patches. This was reflected in relatively high values of the shape index (nearly 2). In consecutive years, however, when traditional agriculture gave way to the irrigated mechanized type of agriculture not linked to natural attributes, the shape index dropped to minimum values (near 1.5), reflecting artificially regular polygonal patches.

Several studies, mainly in more humid regions, have emphasized the relationship between landscape ecological attributes of patch number, size, and shape, and the biodiversity, species evolution, and species ecological behavior. For example, Luque *et al* (1994) in their study of temporal and spatial changes in an area of the New Jersey Pine Barrens landscape indicated that their whole study area experienced fragmentation between 1972 and 1988. This landscape fragmentation is revealed in the significant decrease in the background classes patch size, accompanied by an increase in the number of patches and the amount of their perimeter (edge). They argued that the observed fragmentation process may lead to insularization and habitat loss, processes that may, in turn lead to a decline in biological diversity. They added that the number of species depends strongly on fragment size, and fragments smaller than 10 hectare will tend to be species poor. Therefore, the increase in the background patches smaller than 10 hectare, can be assumed to indicate a possible decrease in species diversity in this region. If this arrangement is applied to the present study area, these fragment sizes may not be the same, because of the different nature of the arid environment.

The effect of several land use practices on species diversity in the western Mediterranean coastal region of Egypt, where the pilot area of the present study is located, was assessed by Ayyad and Fakhry (1997). For example, undisturbed (non-fragmented) sites of natural vegetation were compared with others which were fragmented by construction of summer resorts on the coastal dunes for species richness, as well as for species dominance and evenness. In sites of active dunes (dynamic) the trend was a decrease in species richness in fragmented (disturbed) sites than in non-fragmented (undisturbed) sites; this was associated with greater dominance of *Ammophilia arenaria* (Marram grass) and *Lotus polyphyllos* (Leguminous perennial herb) which persisted disturbance. In the more stabilized dunes, the general trend was also a remarkable decrease in species richness from 17 to 6 species per site and an increase in dominance of *Ammophilia arenaria* in fragmented sites; it was also remarkable that the annual species were not detected in those sites.

Considering the visual data, it is most usually convenient to select those attributes that do not depend on extensive fieldwork or that are biased by researcher opinion. If, for instance, decisions about scenic resources could be made by resorting to spatial data banks, the landscape manager's task would be greatly facilitated (Brown, 1994).

Visual data and proposed attributes used in the present analysis were selected after a comprehensive examination of relevant literature (e.g. Zube *et al*, 1975; Mooney, 1983; Smardon and Fabos, 1983; Brown, 1994; Crawford, 1994). The specific features of the pilot study area were taken into consideration in this selection. Characters such as the density of tree cover, for example, used by Brown (1994), were eliminated because of the scarcity of trees especially in natural vegetation cover in the study area. Other characters that have been introduced by Mooney (1983) and Smardon and Fabos (1983) also were eliminated, since they were specific to wetland assessments.

In the present study, two visual attributes were selected for assessment in the pilot study area: land use/land cover *diversity*, and *activity* (degree of naturalness). The two attributes summarize a conceptualization method that could be used in visual resource management. Many other factors may affect the selection of visual attributes, scale, climate, region, and seasonal changes. Crawford (1994) for example, has presented an evaluation of using remotely sensed images in visual quality assessment. In using such images, scale consisted a major factor in delimiting the visual attributes of the study site. In this evaluation, the spatial resolution of the utilized sensor (Landsat MSS[1], 80m spatial resolution) formed an obstacle in achieving better results. The difficulty encountered by Crawford (1994) was mainly overcome in the present study by using remotely sensed data generated from higher resolution sensors (SPOT[2] XS and Panchromatic), together with digital elevation models to assess visual attributes.

Concerning the change in these visual attributes, the results of the present study indicated a general trend common to most sectors. This trend was towards the increase of land use/land cover visual diversity. This may be attributed to the introduction of several man-made activities which consecutively increased the artificial classes of the degree of naturalness in the area.

[1] Landsat Multi-Spectral Scanner satellite system
[2] Système Probatoire de l'Observation de la Terre.

In this connection, Crawford (1994) asserts that there is a large body of evidence to support the use of certain identifiable landscape dimensions in the assessment of visual amenity. Scenic quality increases as topography ruggedness and relative relief increase, presence of water forms, water edge and water areas increase, patterns of natural vegetation become more diverse, natural landscapes increase, and man-made landscapes decrease, land use compatibility increases and land use edge diversity decreases.

Accordingly, it may be concluded that the analysis of change detection of land use/land cover of the first sector indicates a general deterioration in the visual attributes. In the first sector in particular, such deterioration calls for special attention. This sector is credited for its wonderful coast formation, and the clear azure water color. The topography offers a diverse, vital landscape of even sandy beaches with frequent lagoon depressions and pure white sand dunes. Holiday-makers and tourists are often attracted to its beaches for periods varying from few days up to the whole summer.

There is a good number of reasons why society should be concerned about the visual quality of the environment. Many of these reasons relate to the so-called incommensurable values - those that are difficult to measure in conventional terms yet constitute some of the most important underlying values in society. Some authors have discussed these reasons (e.g. Dearden, 1980; Knopf, 1983) and all have one thing in common: they are very difficult to measure.

6.1.2. Mariut ridge and the inland plateau

Concerning the change in ecological attributes of the second group sectors (the third sector represented by Mariut ridge and the fifth sector represented by the inland plateau), it may be noted that, with minor differences, the trend of change was the same in both sectors: greater number of natural patches in 1955 which decreased and became of larger size in 1977, and again an increase in the number of patches associated with a decrease in area in 1987 and 1992. The first phase of this trend between 1955 and 1977 could be attributed to the abandonment of rain-fed cultivation by Bedouin due to the attraction of inhabitants to other economic activities related to irrigated agriculture, quarrying and construction, social services, and transportation. The second phase of the increase in number of patches and the decrease in patch area of the background class (natural vegetation and bare soil) could be attributed to fragmentation induced by the spreading of quarries and construction sites.

6.1.3. The saline depression

In the third group of sectors represented by the salt marsh (the saline depression) located between Abu Sir and Mariut ridges, only slight fluctuations occurred in the ecological attributes. These fluctuations may be attributed to seasonal variations in rainfall. Following winter and early spring the flooded patches increase in size and number on the expense of the salt marsh vegetation, and the contrary happens during summer and autumn. Another important factor affecting these fluctuations is the irrigation canal south of the sector from which underground seepage of irrigation water may cause flooding of patches in the salt marsh during the periodical pumping of water into those canals. Factors which caused permanent changes in these ecological attributes are the artificial drying of patches for construction of residential buildings, industrial activities of salt extraction, and the deserting of rain-fed agriculture by the Bedouin at the fringes of the salt marsh.

6.2. Background of socioeconomic activities

In the present study, an attempt was made to correlate the changes in the socioeconomic attributes and the evolution of the ecological and visual attributes of the landscape. First of all, it is important to note that the Bedouin settlements differ completely from the concept of an agglomerated village of the Delta and Nile valley. Here a settlement usually refers to a group of scattered houses and tents covering a large area of land. Agriculture and even grazing may take place between houses. A settlement in this case refers to a number of houses that are relatively close to each other and are linked by tracks, a road or a common wadi. In addition, main linkages (like the coastal road and the railway parallel to it) have greatly affected current sizes and locations of settlements. With tendency to sedentarization, the Bedouin social organization became of three mutually dependent types of communities: urban, rural, and pastoral. Each type has a distinctive mode of life and operates in a different setting, but each sector still contributes to the support of the other two, thereby maintaining one total social system.

The national goal was to settle the largest number of Bedouin in order to create a socially stable society by the implementation of large-scale development projects including land reclamation and intensive agriculture, introduction of economic crops and farm cattle (cows and buffaloes beside goat and sheep), and establishment of industries. All this had far-reaching impacts on the physical and socioeconomic attributes in the region. This development process at its initial phase, attracted the Bedouin to settle in order to benefit from the newly established utilities, and to promote their standard of life. This soon resulted in changes in the cultural values of the Bedouin and their understanding of social development. This was clearly reflected in the increase in the level of elementary and graduate education among their children, and the promotion of culture exchange between the Bedouin society and the new settlers from the Nile valley. Besides, there was an increasing tendency of the Bedouin towards maximizing their income by deserting agricultural activities (a total decrease in the total number of inhabitants working in agricultural activities from 70.7% in 1960 to 41.6% in 1986) and concentrating more on selling land, commerce and construction.

In conclusion, this process pushed the socioeconomic system of the region from a self-sustained subsistence system to a regime of market economy linked to national production and depending heavily on input of material, energy and labor, and in which the region's natural resources and agricultural economy assumed minor importance. It is remarkable that in spite of the active increase in construction and tourism industries, and the high rate of urbanization in both Burg El-Arab and El-Hammam, the Bedouin did not gain significant benefits as shown by the rate of employment in these activities which remained unchanged between 1955 and 1992 (the percentage remained unchanged (8.9%) from 1960 to 1986). This demonstrated that the large investors and companies depended mainly on inputs of labor from large urban centers (Cairo and Alexandria). The Bedouin themselves, aware of the remarkably increasing value of their land, gave up agricultural activities, especially along the coastal sector. Furthermore, most of the land sellers near the coastal highway tended to move inland and buy agricultural land instead of what they gave up in the coastal sector. This resulted in the increase of the population pressure along the railway line and along Bahig canal, particularly in both Burg El-Arab and El-Hammam (also reflected in the increase in the total area of the built-up patches from 1.5% in 1955 to 9.1% in 1992). It is remarkable that the built-up areas were unplanned in the absence of a national urban policy for the region.

The social fabric and the demographic structure witnessed another major upheaval by the increase in the number of immigrants from the Nile Delta and El-Arish. Awlad Ali, the main tribe living in the region (refer to Chapter 3 "the study area"), became no more the dominating tribe, especially after the settlement of new investors who owned some of the reclaimed land. Disputes occurred between families and individuals for land ownership after the increase of its value, and Bedouin values, traditions and lifestyle changed. They also accepted the ideas of women education and work, and changed their attitudes of superiority and inferiority between tribes. Women began to share men in work beside children raising and housekeeping. This was clearly reflected in the increase of the women workers from 2.4% in 1955 to 5.3% in 1992 as demonstrated in the "Results" (chapter 5). This resulted in some changes in their social equilibrium, which was mainly reflected in the increase of the age of marriage either for men or women due to women education, expensive dowries, and marriage expenses. This also changed the marriage selection criteria, as the within-tribe marriage decreased in favor of individual selections from other tribes and even from outside the region (Ibrahim *et al*, 1989).

The immigrant population introduced important cultural and social changes to the original lifestyle of the Bedouin, which gave the opportunity to further social interactions between them. This raised some problems of worry, from the side of Bedouin to lose their land, which they occupied for hundreds of years. But, on the other hand, they learned from the immigrants' new techniques of agriculture and construction.

In the following parts, an overview of the obtained results will be presented in order to review the importance of the application of concepts of landscape ecology in the northwestern coastal region of Egypt. Benefits and drawbacks of the adopted framework shall also be discussed in order to reveal points of interest in the analysis of the landscape under investigation.

6.3. Evaluation of the adopted framework

The adopted framework is based on the three poles of landscape components: ecological, visual, and socioeconomic. The gathered data were mainly spatial, i.e. they were concerned with land cover and/or land use. This was mainly acquired through remotely sensed sources (aerial photographs and satellite images), which were readily available. On the other hand, the non-spatial data (e.g. socioeconomic) were difficult to gather. They were collected mainly from census reports which were, in some cases, not available for consultation, or simply missing. In summary, the landscape components taken into consideration were, in some cases, useful in conducting the analysis, while in others, they were very limited due to lack of data. This is discussed further in the following part.

6.3.1. The ecological attributes

As presented in the previous chapter, the ecological attributes of the landscape emphasized the process of change in landscape from natural to more and more artificial human occupations. This was clearly reflected in the decreasing shape index of the natural patches in the arid landscape under investigation. In some cases, this index proved to be a good indicator of change in the ecological features. For example, in the first sector (the sand dunes and the first depression), the dissection process of the main patch of the sand dunes on the coast was very clear in the later years of the period of analysis. The destruction of the natural vegetation, which works as a sand-stabilizing factor, with the construction of large settlements of summer resorts, and by the substitution of the natural environment by other imported elements and components, was obviously reflected in the increase in the total number of sand dune patches, and the decrease in their size and shape index, which demonstrates a transformation from irregular natural shapes, to more isodiametric man-made shapes.

It is known that for the more humid regions, changes in area, number, and shape of patches cause changes in species richness, distribution and persistence of population, and probability of disturbance (Fahrig and Merriam, 1985; Freeman and Merriam, 1986; Franklin and Forman, 1987; Van Dorp and Opdam, 1987). Different man-made elements in the landscape are basically isodiametric in shape, but should possess lobes and convoluted boundaries to assist inter-patch dispersal and edge usage by wildlife, as well as providing visual complexity (Selman and Doar, 1992). Also, Forman (1995) describes the relationship between shape of patches and their ecological function:

> *"To accomplish several key functions, an ecologically optimum patch shape usually has a large core with some curvilinear boundaries and narrow lobes, and depends on orientation angle relative to surrounding flows... a compact or rounded form is effective in conserving internal resources, by minimizing the exposed perimeter to outside effects (Harris and Kangas, 1979). But patches affect, and are affected by manifold ecological processes in a landscape. Interactions with adjacent ecosystems are enhanced by curvilinear boundaries. Interactions with more distant portions of the landscape are enhanced with narrow lobes."*

However, there was some ambiguity regarding the meaning of the three ecological attributes when explaining their change in natural and man-made areas. This may call for further assessing the relationship between these attributes (number, size, and shape index of patches) in the arid coastal environment of the study area.

The five spatial processes explained by Forman (1995) (perforation, dissection, fragmentation, shrinkage, and attrition) proved to be active in the study area, and that they are changing in different magnitudes. However, the relative importance of each of these processes in the arid environment of the study area should also be evaluated, because their ecological roles and impacts could not yet be evaluated and interpreted as clearly as they could be in more humid regions.

For these regions, Forman (1995) evaluates the size of patches and their ecological meaning:

> *"Large natural vegetation patches are the only structures in a landscape that protect aquifers and interconnected stream networks, sustain viable populations of most interior species, provide core habitat and escape cover for most large-home-range vertebrates, and permit near-natural disturbance regimes... large natural vegetation patches serve many major ecological roles and provide many benefits in a landscape. Consequently a landscape without large patches is eviscerated, picked to the bone. A landscape with only large patches of natural vegetation misses few values. On the other hand, small natural vegetation patches serve as stepping stones for species dispersal or re-colonization, protect scattered rare species or small habitats, provide heterogeneity in the matrix, and habitat for an occasional small-patch-restricted species. In effect, small patches provide different benefits than large patches, and should be thought of as a supplement top , but not a replacement for large patches. An optimum landscape has large patches of natural vegetation, supplemented with small patches scattered throughout the matrix. Alternatively, most of the small-patch functions can be provided by small corridors in the matrix.*

One of the major issues that can be of significance to the use of ecological landscape attributes is scale. This may determine the appropriate tools and methods necessary for analysis, especially in the arid environment where natural vegetation and specific types of land use/land cover may be dispersed and sparse, and sometimes cannot be detected by common tools. The size, number and shape of patches are dependent on the scale of study which, in turn, is determined by the spatial resolution of the utilized sensors (Trotter, 1991; Benson and MacKenzie, 1995; O'Neill *et al*, 1996; Qi and Wu, 1996).

On the other hand, the utilized tools and methods to study the ecological attributes proved to be efficient only at the regional scale in arid and semi-arid environments. The satellite images and aerial photographs provide a bird's eye view about the region as a whole, but the level of aggregation accuracy of land use/land cover classes remains questionable because of the sparse natural vegetation and the similarity that exists between the reflectance of the sand-covered areas and some of the built-up zones. This calls for further studies of the relationship between the sensor's capabilities, concerning scale, and the objectives of landscape analysis concerning the ecological attributes.

6.3.2. The visual attributes

Two categories of visual attributes of landscape were considered in this study: diversity, and activity (degree of naturalness). By taking into account these attributes, the present study may be considered as the first attempt to incorporate some aesthetic aspects in the analysis of the landscape resources in the northwestern coastal region of Egypt. Even though it did not carry out this analysis in-depth, it represented an example of what can be done in further consideration of an incommensurable resource. Furthermore, in applying tools of satellite remote sensing and aerial photographs to map and to calculate the quantities of visual attributes, it was demonstrated that many of the visual resources of the landscape can be mapped and analyzed using these data sources.

Many studies (e.g. Zube *et al*, 1975; Burdge, 1983; Smardon, 1983) have indicated the importance of aesthetics to visitor satisfaction levels and some (e.g. Burdge, 1983) have documented activity displacement as a result of aesthetic deterioration. Tourism resource base may be compromised by failure to integrate scenic values into resource management decision making. Yet to the best of the author's knowledge, the Egyptian government has undertaken no studies, employed no personnel nor adapted any specific methodologies for undertaken aesthetic evaluations.

In this respect, Dearden (1988) asserts:

> *"we should be concerned about incorporating landscape evaluation methodologies into our planning decisions, not only because of the importance, but also that to do so is a sound economic decision. This approach is taken simply because many decision makers, despite utterances to the contrary, still seem to be most susceptible to arguments couched in economic terms."*

Tourism, one of Egypt's fastest growing economic sectors, is also a resource-based industry. The desired consequence is economic well-being, but instead of harvesting a resource and taking it to the market, the market is attracted to the resource through tourist visitation. Tourists visit because of the favorable image generated by resources in an area. Dearden (1988) adds that the resources generally comprise two categories. First are the attractions in the area, which may be natural, totally human built, or anywhere in-between these roles. Second is the tourist infrastructure that allows the visitor to reach the attractions with comfort. Most income related to tourism is generated through the infrastructure, and most attention should be devoted to this aspect of the resources base.

The present study of the visual aspects of the landscape can be extended to include other visual attributes, e.g. color, water bodies, water body edges, topographic changes, visibility, visual accessibility ...etc., and non-visual attributes, e.g. other senses such as smell, touch, symbolic values ...etc. It is notable that this type of studies is completely missing in the planning process in Egypt, and therefore, special emphasis should be given to further studying and evaluating the importance of aesthetic resources to the planning and management processes in arid coastal landscapes of Egypt. Therefore, the adoption of high technologies of satellite image processing and aerial photographs interpretation need to be adapted in terms of studying the evolution of the visual attributes of the arid coastal landscape, with emphasis on issue of scale, and better applications for more accurate results.

6.3.3. The socioeconomic attributes

The availability of socioeconomic data, as it may be noted, is very limited, specially in developing countries. Important data of the socioeconomic changes in the past are either missing or very difficult to obtain. In this study, the main problem encountered was to identify reliable sources of socioeconomic information about the study area during the past fifty years. Relatively accurate census data can be found only for large urban agglomerations and for sites that were once selected for large development projects. The whole nation was not precisely covered for the antecedent years. Almost all the collected data were more concerned with demographic than economic data. Only two types of socioeconomic information were found for the period from the fifties till the nineties: the population age distribution and sex, and their economic activities.

The collected data and the subsequent presentation of their treatment yielded approximate figures about the future distribution of the population. Also the changes in the economic activities of the inhabitants exhibited a remarkable increase in the contribution of women in the work market, although their percentages did not increase proportionally. These data, as they reflected fairly good information about the global status of the population in the area, are not sufficient to further discern the role of the social and economic evolution in changing the landscape.

In two individual but connected disciplines, the socioeconomic aspects were presented in several studies of the landscape. It has to be noted that the social and the economic components of these attributes are inter-connected as are many of the landscape elements. Social and ecological components, economic and aesthetic components, and political and economic components can be regarded as examples of such inter-connection as was previously depicted in the statistical analysis in Chapter V (RESULTS) . These disciplines are not only interrelated but they may overlap in most cases. Each of the economic and social attributes of the selected study area can form a subject for study by itself.

Many authors asserted the importance of the study of the socioeconomic attributes of the landscape in order to understand its function. Medley *et al* (1995) noted that the changes in population density, economics, and technology are often considered principal determinants of land use change. The complex of the physical, biological and social forces makes the landscape unique to each region (Kamada and Nakagoshi, 1996). However only few landscape studies attempted to integrate the socioeconomic attributes with landscape ecological attributes, but in a more or less descriptive manner (e.g. Nakagoshi and Ohta, 1992; Ispikoudis *et al*, 1993; Medley *et al*, 1995; Kamada and Nakagoshi, 1996).

It has to be noted that other social and economic factors need to be integrated in the analysis in order to understand the changes in land utilization and resource use. Factors such as national policies and their impacts on the evolution of the socioeconomic and ecological elements need to be considered in further studies. An historical overview of the evolution of the political system in Egypt in general and in the northwestern coastal region in particular may contribute to the interpretation of its landscape evolution.

Another important element is the monitoring of the planning process in Egypt. The study of the decision-making process will help identify other factors and define other actors responsible for landscape change. Accordingly, three main questions may be proposed: what are the main factors to be taken into consideration in analyzing the northwestern coastal landscape of Egypt, what is the reason to select those specific factors, and how can we incorporate them in the analysis of the specified landscape? In the following chapter these factors are discussed and evaluated, and an attempt is made to answer these questions.

6.4. Statistical treatments

The statistical analyses applied in the present study were carried out with two objectives: (a) to assess the interrelationships between landscape attributes and to evaluate their interactions, and (b) to assess the significance of variation of each attribute with relation to time and habitat. The multivariate analyses indicated that some attributes were correlated to other attributes of a different group than with attributes of the same group. For example, three visual attributes (8-artificial visual activity, 12-artificial/natural visual activity, and 4-no visual diversity) correlated more to most of the socioeconomic attributes (attributes from 15 to 34) than to other visual attributes. Besides, the ecological attributes, in general, tended to be correlated to the visual attributes more than to the socioeconomic attributes (refer to Figures 5.23, 5.24 and 5.25). Therefore, it is important to take into consideration such correlations in further landscape analyses and in planning of the northwestern coastal region of Egypt. The two types of multivariate analysis (ordination and classification of attributes) are also useful in constructing a landscape model. To start with a simple version of the model, the attributes closely related in one cluster, may be treated as one entity or a few entities with the assumption that they vary together, and that their variation may be expressed by a collective index (e.g. social and ecological indices). On the other hand, the attributes that are not closely linked together in one cluster will need to be included individually in the model.

The assessment of the significance of variation in landscape attributes with time and habitat by applying the analysis of variance, helps in constructing a landscape model in two ways. First it would provide a basis for prioritizing the attributes to be selected for inclusion in the model at different levels of elaboration, depending on the degree of significance of variation in each attribute. Those that exhibit higher significance, would be given higher preference than those that exhibit lower significance. Also, such statistical treatments would have been useful for landscape ecological studies, which aim at selecting specific landscape attributes (e.g. O'Neill *et al.*, 1988; Musick and Grover, 1991; Kazaklis and Karteris, 1993; Hulshoff, 1995; Qi and Wu, 1996; Riitters *et al.*, 1996), or for applying them in understanding specific landscape phenomena (e.g. Nakagoshi and Ohta, 1992; Simpson *et al.*, 1994; Kamada and Nakagoshi, 1996) without either evaluating the interrelationships between these attributes or assessing the degree of importance of each attribute for their specific study areas. Futhermore, these statistical treatments would have been useful in studies concerned with landscape analysis in Egypt, which attempted to explain ecological and physical changes in connection with socioeconomic/cultural factors without assessing the significance of their interrelationships and their impacts (e.g. Ayyad and Le Floc'h, 1983; Kamal, 1988; Salem, 1989; Ayad, 1996). This may lead to inaccurate interpretations as a basis for planning and management of the selected study area.

The second way in which these statistical treatments may help in constructing a landscape model is that it provides a basis for regression equations expressing the forms of variation in landscape attributes with time. These forms could then be applied in depicting the dynamics of the landscape, and providing simulations which predict future changes in these attributes, which may be useful for landscape planning of the study area.

6.5. Remote sensing and GIS

Data and computational limits used to be an obstacle in landscape analysis and in constructing simulation models of landscape dynamics. Now these limits are becoming less significant, due to advances in remote sensing for change detection, and in the incorporation of remotely sensed data and auxiliary data into Geographic Information Systems (GIS). But although there are now substantial data on how much and what kind of landscape change has occurred, remote sensing change-detection studies seldom include explicit modeling of change processes (Baker, 1989). Similarly, for modeling important processes, the GIS data management framework is increasingly essential, and is receiving substantial research attention, but models of landscape processes using GIS have been rarely developed. The present study has utilized these two techniques in generating and organizing data of changes in landscape attributes in the western Mediterranean region of Egypt during the last few decades that can be utilized in building such model.

The following chapter which provides a framework for developing a landscape model for the study area will demonstrate the merits of both applying the statistical tests discussed above, and of utilizing the capabilities of the techniques of remote sensing and GIS in generating and organizing valuable data of landscape attributes in developing such models.

Chapter VII: Towards A Model For Landscape Planning

In this chapter, a model framework for landscape planning is proposed for application in the western Mediterranean region of Egypt. It will be presented in view of the major issues discussed in Chapter VI (Discussion). This framework takes into consideration the main factors affecting landscape structure and dynamics, the main concepts of landscape ecology with respect to the specific characteristics of the designated arid coastal landscape, and the merits of the applied statistical tests and the techniques of remote sensing and GIS. It utilizes the information which is currently available about landscape attributes of the study area, and keeps the option of iteration whenever new information becomes available. In the previous chapters, the present study revealed and stressed on several problems in the northwestern coastal zone of Egypt. The main problem is the absence of a planning model and the chaos in decisions regarding the management of landscape evolution. This is clear in the stress on the direct economic gain with a clear lack of understanding of the landscape, which is revealed in different institutional and local levels, from decision making to the anticipation of the local inhabitants for a better life. Besides, the study of the significance of variation within and between the presented attributes can form a strong basis for a comprehensive data gathering methodology that prevents the aggregation of insignificant variables in the analysis of the landscape.

Consequently, three subjects should be clarified, as they form a basis for any planning model of the northwestern coastal zone of Egypt: The political and socioeconomic changes, bedouin adaptation to the arid environment, and the institutional planning framework. Those entail the importance of three cornerstones of the proposed planning framework that will be described later in this chapter. First is the public participation in all phases of the model, second the capacity building on both the local and the institutional levels, and finally the filling of the information gaps to ensure a reliable and coherent sources of information throughout the planning process, which is mainly dependent on the methodology presented in the previous chapters.

The findings presented in the preceding Chapters of this thesis are linked to this model framework. Thus, in presenting the activities to be achieved for the practical application of the model, the prominent features of the study area, as well as the methods and results obtained in the present study that are related to each of these activities are integrated with their respective activities.

As a prelude to presenting this framework, a brief account will be presented in this section on the driving forces of landscape change in the study area.

7.1. Driving forces of landscape change in the study area

The previous chapters indicate that the landscape of the western Mediterranean region of Egypt is influenced by socioeconomic, cultural and political variables beside the ecological variables taken into account by the present study. In this respect three driving forces may be identified: political and socioeconomic changes, adaptation of local inhabitants to the arid environment, and the institutional planning framework.

7.1.1. Political and socioeconomic changes

The history of the northwestern coastal region of Egypt (Mareotis) witnessed socioeconomic ups and downs due to radical changes in political decision-making. The region acquired economic and political significance in the Graeco-Roman period. The aim has often been to extend the occupied territories and to enforce beliefs. Establishing extensive agricultural practices was not to create a sustained economic base but mainly to serve the capital[1]. Towards the end of the 4th century, with the

[1] E.g. Rome in the Roman era: the title "Rome's Granary" was once given to the north African coast in preference to the Nile-irrigated black land. The black land was naturally part of the granary, but to extend the name as far as Numidia (present day Algeria) shows that the river-irrigated and the rain-fed lands were on equal footing in producing grain (Ayyad, 1978). The same situation prevailed also during the British occupation of Egypt in the late 19th century when the Nile Delta and valley were confined to cotton production which served as a main source of production for export to England.

division of the Roman Empire, the Egyptian coast and Cyrenaica[2] fell to the Eastern Empire at Byzance (Constantinople). With the fall in Byzantian demand for Egyptian grain, the region to suffer would be that whose economy is geared for export of products and not for subsistence. Thus Mareotis suffered more than the Nile valley and Delta. Later on, when the Arab came in 642 AC, they found the region very similar to that of their homeland, suitable only for grazing and minor rain-fed cultivation. The Arab interest to develop it was minor to the favor of the capital and the Nile delta and valley.

During the first half of the 20th century, Egypt witnessed some political and economic changes. As a result of these changes, several population migrations altered the social fabric in the western coastal region. These migrations occurred mainly for economic reasons, and were first manifested in the movement of the Libyan population to the region when it furnished a good trading market, and from the region to Libya when oil was exploited in the early seventies. It was also manifested in the immigration of some of the population of the Nile Delta and valley to the region; this occurred after extending canals in the late sixties for new irrigated agriculture. Immigration to the region due to wars happened two times, in 1956 and in 1967 by the populations of Sinai and the Suez Canal region and when the immigrants settled in the region even after the peace treaty. They integrated with the new society and influenced the Bedouin with some of their culture and habits. Now, in Burg El-Arab and El-Hammam, (the sites of the present study), the social fabric is a mixture of Bedouin, and inhabitants from Suez Canal region and Nile Delta. But further inland, far from large villages and urban agglomerations, the Bedouin customs and habits still prevail. Again, as was previously practiced during the Graeco-Roman and Byzantian time, the nation used resources of the region not only for subsistence economy, but also to serve the national capital and major cities.

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[2] Cyrenaica is the area northeast of Libya

In the meantime, the national attention was directed to developing the Bedouin societies, and the land tenure system was gradually changing from the conventional tribal form, to a more legislative, government managed system. New land reclamation projects were applied (e.g. the extension of irrigation canals, land reclamation projects, health-care programs...etc.), and many Bedouin converted their activities from simple goat and sheep herding to extensive irrigated agriculture. This raised the value of land and pushed the families and the individuals to settle and to seek land ownership independently from their tribes. The conventional tribal sense of land use was consequently weakened, and remained only further inland far from land reclamation and development projects.

These changes led to modifications in the economic system from a structure based on pastoralism to a structure based on a multiple-use strategy (a group of economic activities in which agriculture has an increasing role). These modifications are clearly visualized by the present case study of the evolution of land use types and human settlements from 1955 to 1992, by the analysis of remote sensed data, and the interpretation of population census data. Based on these data, for example, the assumption could be made that there is a significant decrease in pastoralism as indicated by almost complete abandonment of traditional (nomadic) tents to large sedentary types of settlements. This is clearly represented by the growth of both Burg El-Arab and El-Hammam urban centers.

In arid and semi-arid lands, one finds nomadic populations. Their numbers, status and importance have changed through the centuries. They include very primitive as well as quite advanced populations. They roam over smaller or wider areas in the region they inhabit, mobile and always traveling light (Hills, 1966). Today, in the western Mediterranean region of Egypt this is not mainly the case. The Bedouin traditional social organization has three mutually dependent types of communities: urban, rural, and pastoral. Each type has a distinctive mode of life and operates in a different setting, but each sector still contributes to the support of the other two, thereby maintaining one total social system. It is, therefore, primordial to note that the study of the impact of development on social status is extremely important. The social characteristics should be considered as a basic element in planning for development. Besides, setting up a clear policy for land tenure has a vital role in the settlement of local population and in their participation in development programs. Thus, the development process advocated by any landscape-planning model in the study area will never achieve its targets without the full approval and active participation of the local citizens for a number of reasons. The most important of them is that they have doubt about the way the Government will deal with the land tenure system in the area (El-Naggar *et al.*, 1988), and that they cannot be sure that development projects have anything to do with them. Therefore, it becomes necessary to legislate tenure in a way that conforms with the development programs, to actively incorporate people in these programs, and to secure confidence between interested parties. On account of their day to day living in the desert, and their intimate knowledge of the particulars of their environment, the people who work in agriculture and grazing should be actively involved in the discussion and implementation of landscape-planning models.

7.1.2. Bedouin Adaptation to the Arid Environment

The Bedouin has reached the level of being adapted to his environment; he will never, for example, camp in a wadi bed, aware of the mortal danger of a flash flood of winter rainfall. In distinct contrast to sedentary villages in semi-arid lands that often seek high ground for their site, the typical Bedouin encampment is tucked away in some fold of the ground or a small side valley on the slope of a hill for the protection from wind, and concealment from the sight of passing by Bedouin of other tribes and other less welcomed trespassers in the area. In contrast to the nucleated villages, the Bedouin traditional encampments are much more widely spread sometimes a hundred meters or more between one tent and the other. It is generally easy to distinguish a Bedouin village at first sight by the very wide spacing between the houses. This has shaped up the built component of the landscape in the study area. The Bedouin with his keen natural intelligence has not been slow to adapt to the changing conditions; today the nomad of the desert and its borderlands is gradually becoming part of modern society, as a laborer, a truck driver, an industrial plant worker or in building industries. Possibly his brother or sons still take the family's animals to the traditional pastures.

The main economic and social objective then should be to discover whether the present human populations, with their expected increases in the western coastal land of Egypt, could be maintained on an adequate economic plan. In most cases, this is not possible in the present conditions of haphazard land use. It needs to be discovered whether by the reclassification of the land and the application of modern principles and techniques, as those applied in the present study (e.g. remote sensing and GIS), a new sustained and balanced landscape development may be achieved.

7.1.3. The Institutional Planning Framework

Since 1982, the process of development in Egypt has been carried-out in three 5-years national plans. The preparation of the 5-year plan is carried out at three levels: the local, the Governorate, and the national. At the local level, town and village councils submit their investment programs to the districts that submit their collective requirements to the planning department of the Governorate. In the Matruh District for example, the City of Matruh is the capital (markaz). Thus, the towns and villages submit their programs to the City Council of Matruh. At the Governorate level, the planning department coordinates the requirements of the district, local service department and Directorate. Accordingly, any development plan proposal is submitted by the executive council of the Governorate to be ratified by the Governorate people's council.

It is intended that a regional planning center will be established to carry out regional studies and plans in each Governorate. Besides, a high regional planning committee will be formed to coordinate these plans and determine investment priorities at the level of the eight planning regions of Egypt. However, to date, this regional planning center and committee exist only for the Sinai and Canal regions. Thus the Governorate of Matruh still sends its investment proposals directly to the central Government. There is an urgent need to set up a regional planning center in

Matruh Governorate as it represents one of the rapidly growing axes of development of the nation. This need arises in consideration of the size and variety of projects (national and international) as well as the need for a development policy plan for the Governorate in addition to regional development plans, to coordinate agricultural, urban and tourism requirements.

In the northwestern coastal zone, villages rarely exist in the sense of an agglomerated identifiable physical settlement. Thus the territorial "Omda" system (the administrative head of the village in the Nile valley and Delta) is not readily applicable. The Bedouin poorly perceives administrative divisions. Their basic affiliation is kinship which often cuts across administrative boundaries. In the Governorate of Matruh, however, the territorial system is supplemented with tribal representation. Each tribe or sub-tribe whose normally habituated land is largest and most powerful segments are represented by an Omda, the lesser by a "Sheikh". The Omda is the official representative from the tribal society to the Government. Although he is employed by the Directorate of the Interior he is appointed by the governor on the basis of nomination by members of his tribe (Ismail *et al*, 1976). The responsibilities of the Omda are twofold: to convey the needs and opinions of his tribe to the authorities, and to undertake civil status and legal procedures on behalf of his tribesmen. His influence in investment allocation depends on how well he can convince the village council of his case.

7.2. Components of the proposed model

The review in the previous section (the driving forces of landscape change in the study area), indicates that the construction of a landscape-planning model needs to take into consideration the following basic issues. The first of these issues is the participation of the local population in all phases of model construction starting with defining the goal and objectives of landscape planning, and ending with the implementation of the landscape plan. Conceivably, this issue includes the utilization of indigenous knowledge in the determination of the planning options, and the development of the landscape plan. The second basic issue is the strengthening of institutional and human capacity needed for the development and implementation of the landscape plan. The third issue is filling the information gaps, particularly concerning the socio-political and socio-economic elements. This does not imply that the development of a landscape plan has to wait for filling these gaps, but that an iterating feature should be built in the model. This feature would provide the possibility of making use of any new information in reviewing and amending the landscape planning process.

Taking these basic issues into consideration, the following model is proposed for landscape planning in the western Mediterranean region of Egypt. It represents the interaction between four main components, two crosscutting components, and one complementary component. The main components are (1) identification of the goal and objectives; (2) inventory of landscape biophysical and socio-economic attributes, and land suitability analysis; (3) determination of planning options, and development of a landscape plan; and (4) plan implementation. The crosscutting components are (5) local participation, and (6) capacity building. The complementary component is (7) new information input. The activities of the two crosscutting components cut across all the other activities throughout the planning process. The interactive approach of this model ensures that new information input may be considered at any phase of the process or during the implementation of the landscape plan, and a revision is made accordingly of the original objectives, planning options, the landscape plan, and its implementation. This process of review may be repeated, and cycling form of planning is experienced.

The proposed model is addressed to the concerned Departments of the Ministry of Planning and the Ministry of Development, as well as their local Departments of the Governorate of Matruh where the study area is located. An illustration of the sequence of the landscape planning process in the proposed model is presented in the box-and-arrow diagram of Figure 7.1. The following is a description of the activities related to the model components.

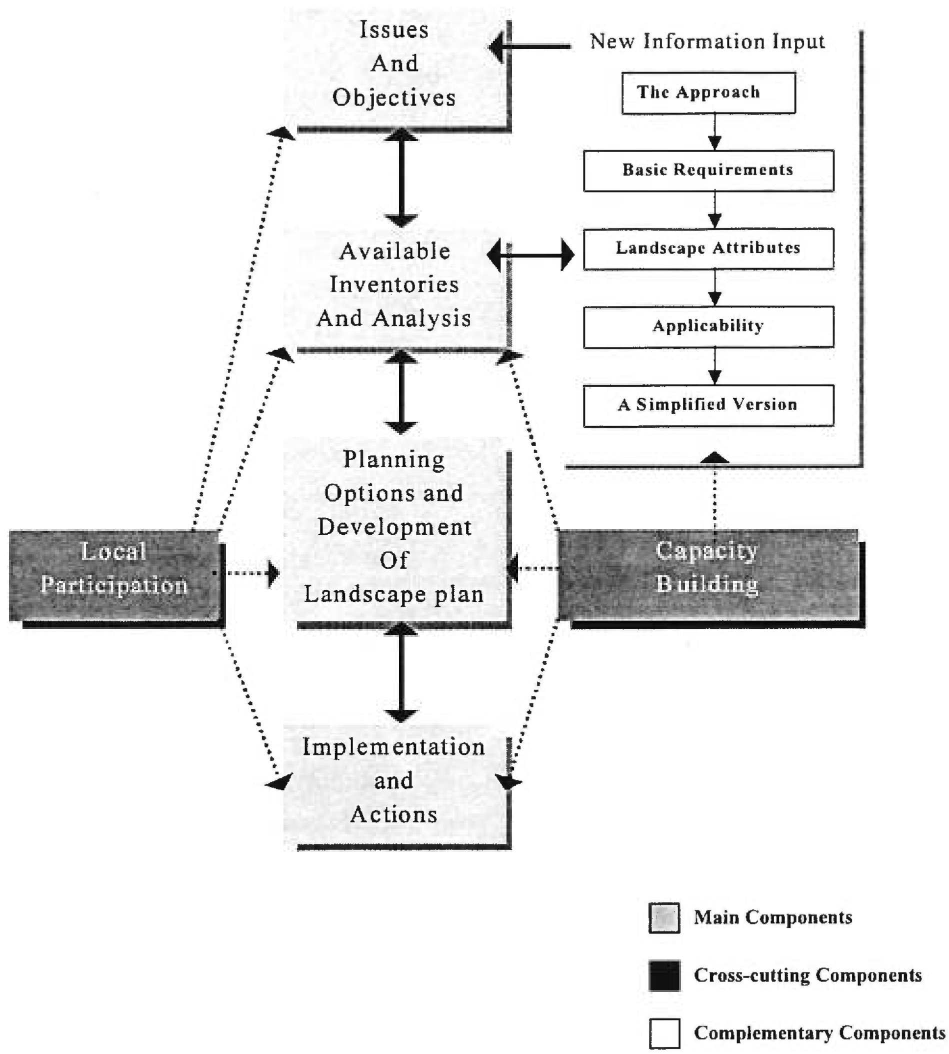

Figure 7.1. Proposed model of landscape planning

7.2.1. Component 1. The Goal and Objectives of Planning and Management of the Landscape in the Study Area.

Activity 1.1. In consultation with the Governor of Matruh, other local government representatives, and the chairpersons of the councils of Burg El-Arab and El-Hammam (the two cities included in the study area), constitute a Landscape

Planning Unit (LPU), and identify local inhabitants to work in it. This unit will also include an environmental officer, a planning officer, and an environmental education officer, and will supervise all the activities of the landscape planning process. It is important to note here that the activities of the LPU have to be coordinated by a well-trained and knowledgeable member. This coordinator has to take into consideration the rationale of different members, and he has to formulate the ideas, recommendations and approaches of the LPU unit in a form that would be acceptable by decision-makers and stakeholders.

Activity 1.2. Organize a public gathering in the study area to introduce the LPU (see component 6, Activity 6.1) to local inhabitants, stakeholders, and decision-makers, and to initiate dialogue to identify the main goal and objectives of landscape planning and management. One of the main nationally recognized goals in the western Mediterranean region of Egypt, for example, is "how to accommodate agricultural, recreational, and other development activities introduced to the study area, while conserving natural resources". The main objectives related to this goal could be: (a) to promote local participation, and to strengthen institutional and human resources capacity; (b) to establish and implement a zoning system as a basis for landscape planning; (c) to promote sustainable landscape resource management; and (d) to conserve endangered life-support systems, habitats, and species.

Activity 1.3. Based on the above mentioned activities form a local advisory committee of knowledgeable individuals from the local community, stakeholders, decision makers, and environmental scientists and planners to formulate the objectives of landscape planning and management in the study area. Although objective setting in a developing country like Egypt is largely dependent on the governmental political will, it is crucial that the people affected be involved in such setting. In this respect, it is encouraging to note that it is a tradition that the decision-makers in the Governorate of the Western Desert used to work in close consultation with the heads and representatives of the Bedouin tribes.

7.2.2. Component 2. Available Inventories and Analyses.

These are mainly inventories and analyses included in the present study.

Activity 2.1. Define the general outline of the area in which the activities of landscape planning are going to be carried out. In the present study, the target area is located between the eastern boundaries of Burg El-Arab city and the western boundaries of El-Hammam city (Figure 3.1), and extends inland for about 20 Km from the sea coast (refer to Chapter III: "THE STUDY AREA" for more details).

Activity 2.2. Collect and analyze the available information of landscape attributes of the study area, and utilize the landscape analysis carried out by the present study, particularly the land use/land cover classes. Nine such classes were defined applying the techniques of satellite imagery processing, and interpretation of aerial photographs. These are: coastal dunes, crop cultivations, orchard plantations, ploughed fields, natural vegetation and barren areas, built up areas, salt marsh vegetation, flooded areas, and quarries and construction sites (refer to Chapter IV: "MATERIAL AND METHODS" for more details).

Activity 2.3. Consult the "simplified version" of the proposed "Framework for New Information Input" (Component 7e) for supporting landscape analysis by field observations that became easily attained at the time of implementing the model. At this point it has to be stressed that the model does not dictate the inclusion of new data and information. It rather keeps the option of making use of any data or information that becomes available at the time of its implementation.

Activity 2.4. Review the land suitability analyses carried out by governmental departments (particularly the Ministry of Development, and the Ministry of Agriculture), and by different consultancy groups, which classified the study area into land of agricultural and non-agricultural uses.

Activity 2.5. Develop a database system that can be incorporated into a GIS later on.

Activity 2.6. Repatriate the collected information on the physical, biological, socio-economic and aesthetic attributes into the database. This will allow the LPU to gain access and to contribute to an established information base crucial to landscape planning and management of the study area.

7.2.3. Component 3. Planning Options, and Development of a Landscape Plan.

Activity 3.1. Use the information and analyses indicated in the above-mentioned activities to guide the selection of options of landscape planning in the study area, concerning in particular areas of grazing, rain-fed and irrigated cultivations (cereal and other annual crops, as well as orchards), housing, summer resorts, and recreation.

Activity 3.2. Utilize the experience of the Bedouin society at this phase, which is not less important than the phase of setting up the planning objectives. The inherited ability of the indigenous population will be most useful for making proper decisions on land-use allocations, (where to graze, where to cultivate fruit trees or cereals, and where and how to plan settlements. The Bedouin also have devised, over a long period of time indigenous land-use practices and water harvesting devices that need to be conserved and which can provide valuable knowledge for modern production systems).

At this stage, stakeholders and decision-makers will have a number of choices, and there will possibly be conflicts of interest. Also, specific parcels of land may be intrinsically suited for several uses. This activity in the landscape planning process attempts to present possible options within the framework of the LPU to find appropriate mechanisms for conflict resolution. There are many techniques that can assist a community in making choices among planning options. The most popular are the "charrette", task forces, advisory committees, public hearings, synchronized surveys, and goal-achievement matrices (Steiner, 1991).

Activity 3.3. Utilize the results of all the above-mentioned activities in developing a land-use plan, which reflects the landscape management strategies, and includes land use, economic development, nature conservation, recreation and ecotourism.

Activity 3.4. Prepare a landscape plan map representing information collected and decisions reached in the previous activities of the planning process, and reflecting existing land uses and land users.

Activity 3.5. Discuss the landscape plan in an open meeting with decision- makers, stakeholders, and local inhabitants.

7.2.4. Component 4. Plan Implementation.

Activity 4.1. Adapt a system for zonation based on the landscape plan, and according to physical, ecological, biological, social, economic and aesthetic criteria.

Activity 4.2. Identify, in particular, “critical or environmentally sensitive sites” (e.g. of high biodiversity, of scenic value, of prime agricultural productivity, valuable indigenous land-use practices, etc.), for protection or special care for controlling negative impacts of land use.

Activity 4.3. Hold consultative meetings with local tribe heads and inhabitants to obtain feedback and suggestions on a draft of the zoning system.

Activity 4.4. Submit the revised zoning system, incorporating the comments and suggestions to the “Landscape Planning Unit (LPU)” for review and endorsement.

Activity 4.5. In accordance with existing and revised legislation (Activity 6.5), develop detailed regulatory mechanisms and management guide-lines for controlling negative impacts from destruction and exploitation activities.

7.2.5. Component 5. Local Participation.

Ensure the involvement of local inhabitants in all the activities of the planning process. Refer to "Component 1. The Goal and Objectives of Planning and

Management of the landscape in the study area" for a description of how local inhabitants are inserted in different phases of the planning process.

7.2.6. Component 6: Institutional and Human Resource Capacity.

Activity 6.1. Explore the possibility of cooperation with the staff of the Omayed Biosphere Reserve (20- Km west of the study area), and the availability of its offices and other facilities for use by members of the LPU.

Activity 6.2. Promote professional and technical skills among local inhabitants of the study area:

a) Consult the Education Department of Matruh Governorate regarding current professional and technical capabilities of the local inhabitants, and to identify the types and levels of training needed for management of natural resources. Suggested areas of consideration include conservation biology, ecology, protected areas management, environmental education and economics, ecotourism management, computing, etc. Conduct training needs assessment if needed.

b) Provide appropriate professional and technical training (including academic studies in Egyptian universities, and short on-site training) to selected local inhabitants.

c) Provide on-the-job training (technical, managerial, and administrative) to the local staff of the LPU and other personnel involved indirectly in landscape management activities, and select local inhabitants to work with scientists and planners as a kind of on-the-job training.

Activity 6.3. Strengthen capability in national environmental institutions involved in landscape planning and management:

a) Organize national and/or local training workshops on landscape planning and management for governmental and non-governmental personnel.

b) Assess the existing operational capability of national research institutions with a track record and commitment for applied research, which would contribute to landscape planning and management. Based on the assessment, provide support and technical know-how to these institutions.

Activity 6.4. Strengthen environmental awareness to incorporate conservation and sustainable use objectives in landscape planning and management:

a) Conduct regular meetings and workshops between the LPU, the planning team and local inhabitants and decision-makers to enhance knowledge transfer about landscape planning in the study area.

b) Make use of the successful experience and the indigenous knowledge of local inhabitants on landscape zonation, and land allocation for different uses.

Activity 6.5. Review the legislative framework for landscape planning and management, and for sustainable use of natural resources:

a) Identify gaps in the present national laws, sectoral legislation, and their implementation which allow uncontrolled land use, overexploitation of natural resources, violation of indigenous property rights, gaps in treatments of issues, and unrealistic enforcement of regulations. (Refer to the section on "Political Elements" in pages 77 and 78)

b) Based on the outcome of the above item, provide suggestions to both the central Government and the local Governorate for revising the present legislation for better planning and managing the landscape.

Specify in the suggestions the need for enforcement, and for training to develop enforcement capacity.

c) Assist in developing legal agreements between communities and external "prospectors".

d) Develop the legislative framework needed for the implementation of landscape planning and management, specially the regulatory mechanisms and guidelines for exploitation of natural resources and land use allocation. Also of importance is the regulatory mechanism on construction of summer resorts, as well as transmigration to the study area, which will put pressure on its landscape. In this process, ensure the recognition of traditional land ownership, user rights and traditional practices. Most of the needed legislation is decided at the level of the Governorate and can be debated more easily with the concerned authorities at that level. Other legislation may have to be decided by the authorities in the central Government and may need greater effort and time. This may be achieved through members of the parliament, the mass media, and the non-governmental organizations.

e) Develop the enforcement capacity, which will elaborate existing mechanisms such as the local council systems of cities and villages.

7.2.7. Component 7. A Framework for New Information Input.

This framework is demonstrated here as a complementary component, which interacts with the other components of the proposed landscape-planning model, and which triggers iterations whenever new important information becomes available. The demonstration starts with a discussion of the approach adopted for generating new information. It includes the basic requirements needed for achieving this goal, landscape attributes of which the information may be needed (Figure 7.2.), and an evaluation of the applicability of this framework. This is followed by proposing a simplified version of the framework, which may be needed to reinitiate the process of landscape planning during its implementation. Again, it has to be stressed that this model framework does not dictate the generation of such new information, but rather considers this as an option that may be taken whenever needed.

(a) The Approach

In Chapter II (THEORETICAL BACKGROUND) the concepts of landscape ecology are presented. These concepts are as practiced in North America and in Europe where physical and socioeconomic data and information needed for analysis may be readily available and are relatively easy to obtain (e.g. McHarg, 1969; Zube *et al*, 1975; Fabos *et al*, 1978; Ruzicka and Miklos, 1990). The techniques for general "environmental planning", "landscape resource analysis" or "landscape appraisal" were often based on these concepts. They burgeoned in the 1960's, and by the end of the decade, fifteen distinct methods representing "the state of the art" of landscape analysis were identified (Porteous 1996). Most of these methods used political areas or watersheds as base areas. Their goals were to balance the competing demands for land of developers, official agencies and the public. Computer-generated maps were prepared, and land use competition problems solved by the map overlay method. Subsequently models for application in landscape analysis and planning were developed to serve a variety of purposes from exploring the interaction of natural processes to evaluating proposed management treatments. These models were reviewed and categorized by Baker (1989) into three types: whole landscape models (conforming with the holism concept), distributional landscape models, and spatial landscape models, depending on the detail included in the model. Whole landscape models which focus on aggregate phenomena of landscape as a whole are seldom developed due to substantial data demand. The most widely used models of landscape change have been distributional models of which the output is the percentage of land area in a set of classes or element types. Spatial

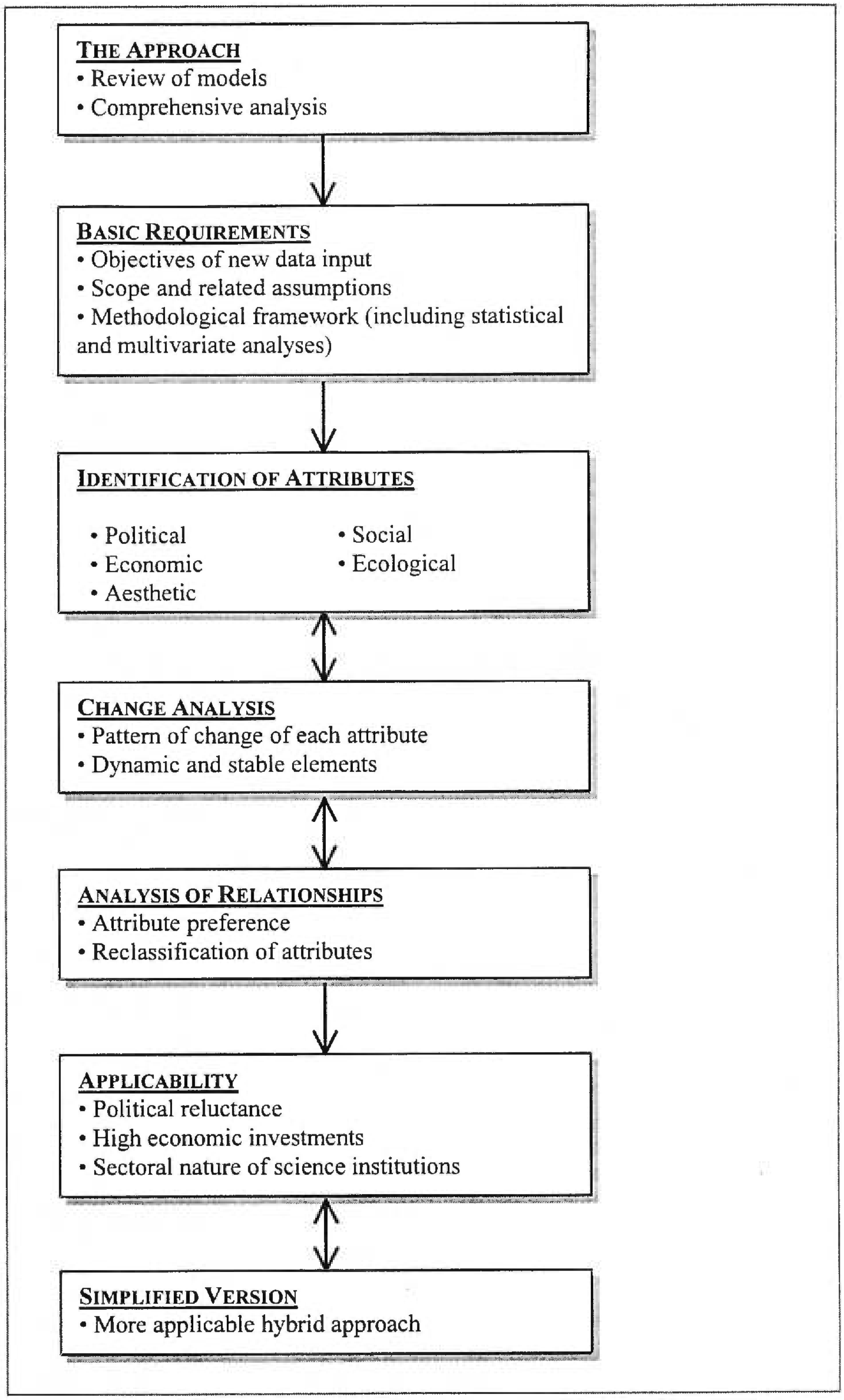

Figure 7.2. Proposed framework for new data input to the process of landscape planning

models that focus on location and configuration of landscape elements have not been widely developed and used, in spite of the necessity of spatial data for answering landscape ecological questions. This may be attributed to the heavy data and computational requirements.

In general, the proposed framework for new data input as a complementary component of the landscape planning model, in the present study, is based on the "holism concept" of landscape ecology, and conforms to some extent, with the "comprehensive planning" approach as advocated by Mcloughlin (1969). This approach is described by Branch (1983) as encompassing conceptually and analytically as many as possible of the essential elements of the "organism" (e.g. landscape) which determine its course of action and its development. It is planning for the total rather than for one or several of its constituent parts; system rather than subsystem planning. It incorporates the best estimates that can be made concerning pertinent events external to the organism. However, it is important at this point to note that it does not attempt to cover every known element and aspect of the organism, but must consider the full range of its components and identify those that are most important and can be handled analytically. This approach is of interest for two reasons (Alden and Morgan, 1974). First, it may be adapted as a means of regional planning where this is seen to involve entirely or in part spatial policy making. Secondly, although Mcloughlin's is only one particular formulation, it may be illustrative of the methodology of systems planning in general, whether in the environmental, economic or social realms.

(b) Basic Requirements

These requirements include the objectives, the assumptions, and the methodological framework and tools necessary for landscape analysis of the study area. Such analysis will help in generating new information that could be used in iterating the process of landscape planning whenever required.

1. Define the main objectives of generating new information input to the landscape planning model in the form of questions to be answered, such as: (a) What are the rates of change in landscape attributes that have occurred during the last few decades? (b) If these rates persist, what would be the landscape structure in the future decades? (c) What would be the expected landscape structure and dynamics under different planning strategies in view of decision-makers' objectives? (d) What would be the landscape structure and dynamics that realize sustainability of the system as one of the main concepts of landscape ecology?

2. Define the scope of landscape analysis and the related assumptions. In the present case study, the analysis encompasses the main ecological, socioeconomic and aesthetic landscape attributes, and their interactions. Examples of related assumptions are the following: (a) The landscape attributes of the study area form an integrated entity. (b) The landscape of the study area is a dynamic entity in which its different attributes are interacting and changing with time. (c) The landscape attributes do not have equal preference in the analysis. This is judged by the degree of significance of variation with time (tested, for example, by the statistical analysis of variance applied in Chapter V "RESULTS"), and accordingly, the number of attributes may be decreased or increased. (d) The landscape of the study area is distinguished into a number of land use/land cover classes; each of these classes may be presented by one or more related types of land use/land cover (e.g. barren areas with natural vegetation, quarries with construction sites, salt marsh vegetation types together, and all types of settlements and buildings together; refer to Chapter IV "MATERIALS AND METHODS"). (e) Some of the closely related attributes (judged by multivariate analyses of the type applied in the present study in Chapter V "RESULTS") can be dealt with as one attribute expressed by an index (e.g. some social attributes may be expressed collectively by one social index).

3. Define the methodological framework and necessary tools of landscape analysis (Chapter IV "MATERIALS AND METHODS"): (a) satellite imagery and aerial photographs at specified dates, expressing the changes in landscape units, and an adequate GIS software; (b) socioeconomic data extracted from national census documents; (c) statistical and multivariate analyses; (d) rates of change due to the interaction between landscape components; (e) mathematical equations representing the forms of change with time in the landscape attributes, (these equations may be based on the results of the analysis of variance applied in the present study; refer to Chapter V "RESULTS").

4. Provide a preliminary list of landscape attributes affected by the human Impacts that are considered as the driving forces of landscape changes (described in detail at the beginning of this chapter).

(c) Landscape Attributes

The aim of the framework of new information input is to initiate an integrated analysis of the landscape attributes of the study area, which leads to the possibility of iterating the process of landscape planning (Fig. 7.2). It has to be noted that such interdisciplinary approach calls for a team of professional scientists, coordinated by a landscape ecologist.

- ***The political attributes:***

The historical changes in the political system in the western Mediterranean region of Egypt have undoubtedly influenced its landscape. The study of its effects is therefore primordial in explaining economic, social and ecological changes. The study of the impacts of changes in the agricultural laws concerning irrigation and land tenure, for example, are major factors that have influenced the socio-economic fabric in the study area. At the level of the decision-making process, it is important to define the roles of the government and the private sector in the developing process. The evaluation of the degree of involvement of local inhabitants and their role in the planning process should also be given high priority.

- ***The economic attributes:***

These include the economic analysis of development projects (tourism, agriculture, industries, ...etc.), such as cost/benefit analysis, as well as the economic activities of local inhabitants. It is also important to analyze the environmental and social impacts of each project and each economic activity in terms of environmental carrying capacity and economic benefit to local inhabitants. The study of the impacts of the national and international import/export systems is also required in order to understand the flow of resources in the region and to quantify the size and importance of the local products. This will clarify the importance of the northwestern coastal region in terms of its role as a national economic source, and guides the policies of landscape planning and management in the future.

- ***The social attributes***

All social attributes have to be linked geographically with spatial elements. This was one of the problems encountered with almost all social data in the analysis of the landscape changes in the study area. The available demographic information is not specific to certain locations with defined boundaries, but is rather an overall indication of the social status of the whole study area. This limited the application of that information in analyzing the impacts of social attributes on shaping the landscape under investigation. Variations in these attributes should be located and mapped in order to study, for example, the impact of sedentarization of Bedouin and their family structure on the landscape.

- ***The ecological attributes:***

It is now obvious that the ecological attributes of the landscape have often been studied in more detail than other attributes. Distribution of the natural vegetation, diversity, and other ecological attributes have been previously studied in depth by many authors. Physical factors have also been covered. All this furnished information for the analysis of landscape ecological criteria. The present study dealt with landscape structure, patch size, shape, number, and distribution, as well as their change during the study period. These changes could, in some cases, be explained with some limitations, and in other cases there was some ambiguity in assessing the significance of their change. This calls for more in-depth studies for a better understanding of the changing nature of these ecological characteristics, especially for the arid and semi-arid regions, because there is no specific evidence that these concepts can be readily applied to these regions in the same manner as applied in more humid regions. The shape indices, for example, may leave some ambiguity when studying some forms of natural and man-made patches, and indices for edge complexity may need to be adapted to describe the regularity/irregularity of the external perimeter of the defined patches.

- ***The Aesthetic Attributes:***

These include what may be called "incommensurable" values that link human senses and perception. In the western coastal region of Egypt, the aesthetic elements of the landscape have never been studied. They were always thought of to be of secondary importance to the management and planning schemes, or were never considered as national resources. It is therefore important to note that the awareness about the value of the visual qualities of the arid coastal landscape needs to be promoted. The population perception and its cultural interactions with spatial visual peculiarities and with changes in the physical land formations need to be evaluated. Furthermore, impact assessments of large infrastructure projects on visual characters have to be carried out in order to reveal the expected changes that may occur in such an important component of landscape after their implementation. Therefore guidelines are needed for further studies of the importance of aesthetic attributes to landscape management and planning for future development.

According to the pre-defined time sequence, the evolution of each of the landscape attributes, based on new information inputs, is then analyzed, the rates of change are calculated, and the dynamic and stable attributes are distinguished. This is followed by (a) reclassification of the attributes; (b) definition of the analysis procedures (e.g. statistical analyses); (c) evaluation of the interrelationships between all attributes, (e.g. correlation coefficients). This analysis can then be used to revise the process of landscape planning. The ultimate objective would be to provide guidelines and recommendations for reconsidering the objectives, planning options, and the implementation of the landscape plan, as well as the programs of public participation and capacity building.

(d) Applicability of the proposed framework: a critical review of the comprehensive approach

It is obvious that the proposed framework for new information input presented above may be relatively too complex to apply, especially in a developing country like Egypt where necessary data and information, and monitoring systems are still lacking. In particular, data concerning socioeconomic and political issues may be difficult or often impossible to obtain. Provided that the basic data and information are available, it is also important to take into consideration the availability of human resources and time needed to conduct such analysis. Therefore, resistance might be expected to this comprehensive approach of landscape analysis and to the research aimed at its implementation. Some reasons for such resistance are addressed by House (1976), which might apply to the Egyptian case study:

1. The policy or action sectors that are expected to meet the costs of comprehensive landscape analysis usually perceive their need in terms of answers or results, not research. Politics is not only one of the most

important elements of comprehensive planning, but also the chief obstacle to its attainment in Egypt. Political decision-makers are often more concerned with the immediate economic gain and with promotion to higher office than they are in devoting the time and attention necessary to perform properly in the office they hold.

2. The broader the scope of the problem, the longer it takes to analyze adequately and the more expensive it becomes. It takes large investments for laboratories, computer facilities, time and institutional change.

3. Universities and other research institutes in Egypt are largely organized on discipline grounds, while comprehensive analysis calls for interdisciplinary efforts. There is also resistance on the part of many researchers and managers toward comprehensiveness for many reasons.

Besides, although Mcloughlin's approach is undoubtedly attractive and persuasive, it is possible to identify a number of potential limitations of it (Alden and Morgan, 1974). It is argued that in such systems approach that a change in one element or part will set off a chain of reactions throughout all of the other parts, and the system planner may be very sensitive to change. It may indeed be the case that this sensitivity is justified. However, this can only be determined given a much more rigorous examination of the system; rather than resuming that everything is related to everything else, it is necessary to find out what is related to what and in what way. This could be estimated by statistical tests as those applied in Chapter V "RESULTS" in the present study (analysis of variance, and multivariate analyses). Unless this sort of examination is carried out, there is the possibility of the system being planned in such a way as to make it more system-like than in fact it is. This may be achieved through, for example, the planner concentrating on giving emphasis to interactions and through viewing the parts too exclusively in terms of the whole and not as entities in themselves.

Accordingly, partial analysis, rather than comprehensive analysis, may in some cases be preferable. Thus, a solid study plan may require a hybrid approach, which keeps the merits of comprehensive analysis, and in the meantime utilizes all available data and information of relevance to landscape planning.

(e) A simplified version

It is important at this point to consider three levels of data availability for application of the proposed model. The first level includes data and information that can be easily obtained and that are necessary to initiate the process of landscape planning (e.g. ecological and physical data, maps and remotely sensed data, and site description). The second level includes data that are not available in literature and can be collected through field surveys, questionnaires, and other quantitative and qualitative methods (e.g. complementary spatial data, some social and cultural data, and other socioeconomic information) as those carried out by the present study. The data and information at this level may also be utilized during the process of landscape planning. At the third level, data and information that are difficult to obtain may be considered. Accordingly, this framework may be kept in its complex form or may be simplified for application according to the availability of data at these three levels. At the third level, due consideration must be given, before spending any further efforts in collecting data and information, to identifying the gaps in understanding of the landscape components and attributes dealt with, and to the expected role of the impacts inducing landscape changes. Greater emphasis may then be directed to the least known components and attributes, and to the factors which play primordial roles. Therefore, a simpler version may be started with in applying the proposed framework of generating new information input for landscape analysis. The application of such version would then indicate in due course of the process whether it would be necessary to add new information. The iterative character of the proposed model allows for making use of any new information whenever it becomes available. The following are actions that may be taken into consideration in generating data and information within the simplified framework.

- **Political elements**

  Agricultural practices

  - Discuss with the local decision-makers the political criteria of the transformation of some areas from traditional rain-fed agriculture to mechanized irrigated agriculture. Conceivably this leads to the transformation of production of subsistence economy to production of market economy, and to linking the economy of the region more closely to the national economy, (refer to Chapter V "RESULTS").

  - Examine the governmental policies of allocating land for agricultural and other production systems and study the impacts (benefits or drawbacks) of such allocation by mapping changes in land use patterns with time. The policies in the study area are directed towards allocating the land with the best soil grades to irrigated agriculture, which results in greater grazing pressure on more marginal land of shallow soil cover or lower rainfall, (refer to Chapter V "RESULTS").

  - Examine the policies of local and the national institutions in pricing agricultural and other products and the implications of these policies on the local inhabitants and on the economy of the region.

Legislation of land tenure:

Before 1964, the Bedouin in the study area were granted the right by the Egyptian Governorate to use the land of Matruh Governorate for grazing and cultivation. But legally, the land belonged to the State. At that time land was not an object of ownership in itself, and wealth was not spoken of in terms of land; the distinction between ownership and usage was hard to work. Ownership rights were then based on tribal customs and law. In 1964 a new law was enacted which recognized Bedouin ownership only where trees were planted before 1964. In 1981, the law allowed for ownership of rain-fed cultivated areas where they have been cultivated during the previous three years. With regard to grazing land, no legislation has been issued to date:

- Explore the reasons for these changes in the legislation of land tenure in general, and the reaction of inhabitants to these changes.

- Evaluate the impacts of these changes, if any, on land-use patterns, population living standard, social values, rate of production, and the national economy.

Decision-making

- Identify the key decision-makers of development in the region and the sectors of the government or the private organizations responsible for monitoring and inspecting the implementation of major projects in the region (land reclamation schemes, industrial settlements, touristic development… etc.). Most of these decision-makers in the study area are senior officials in the central or the regional governmental departments; they have little, if any, knowledge about the principles and objectives of landscape planning.

- Discuss with these decision-makers the impact of the decision-making process on the pattern of land-use and production systems. (This has been evaluated by the present study by comparing land use/land cover patterns between 1955 and 1992).

Development plans

- Examine the existing and future development plans in the study area, and identify the impacts of land reclamation and touristic development on its socio-economy. Obviously, these plans will pursue the activities of irrigated agriculture, and of establishing more summer resorts; these will further intensify the changes that occurred during the last few decades and which were evaluated by the present study.

- **Socio-economic elements**

Demographic aspects

- Evaluate the temporal and spatial changes in the main demographic attributes (e.g. population, age structure, family structure, labor force…etc).

Socioeconomic impacts

- Evaluate the reaction of the local inhabitants to the governmental laws and regulations concerning the development schemes (construction of new towns and touristic villages, land reclamation, land ownership… etc.). For example, since the late fifties when the government decided to develop the Bedouin societies in the western desert, the land tenure system changed gradually from the conventional tribal type, to a more legislative, government managed system. This was witnessed when different land reclamation projects took place (the construction of Bahig irrigation canal, different utilities, and health-care projects, ...etc.), and many Bedouin converted their activities from simple goat and sheep herding to extensive irrigated agriculture which is not affected by the fluctuations in the annual rainfall. This raised the monetary value of land and encouraged the families and individuals to settle with land ownership independent from their tribes. The conventional tribal sense of land tenure was consequently weakened, although it still exists further inland.

- Examine the migration process that occurred to and from the region during the past decades, in terms of density and impact on the social fabric and on the local and national economies.

- Evaluate the effects of these socioeconomic changes on the lifestyles of local inhabitants. (These changes resulted in a sedentary lifestyle of Bedouin, which stimulated the formation of rural and urban settlements. They also resulted in the transformation of grazing and dry farming practices of local inhabitants to practices of irrigated agriculture, touristic services, and labor in construction and industry).

- Examine the process of integration of local inhabitants in the new lifestyle created by the development projects. (The transformation of practices mentioned above led to greater integration of local inhabitants with new settlers in the region).

▪ **Ecological elements**

- Identify the most suitable ecological attributes for application of the landscape analysis in the arid environment of the region. According to the analysis in the present study, ecological attributes that can be included are patch number, size and shape. Inclusion of other attributes such as patch connectivity and diversity needs to be explored for the arid environment of the study area. The evaluation of the changes in these attributes in the present study indicated some important processes such as habitat fragmentation and attrition.

The following tasks need to be fulfilled before carrying out the actions included in this simplified framework:

1. Identify the data and information that are readily available and that may be needed as input for the landscape planning process. These include the existing data and information and those which have to be estimated. Figure 7.3. tabulates the data and information of relevance to the present study.

2. Determine the degree of accuracy, time and scale for each data type, and adopt a data management procedure (GIS) for organizing the new data input and for allocating future inputs.

3. Apply statistical and multivariate methods needed for the evaluation of the overall interrelationships between attributes for final synthesis.

Terms	POLITICAL	Agricultural Laws	Land Ownership Laws	Decision-Making Process	Development Plans	SOCIOECONOMIC/CULTURA	Interactions and Impacts	Demographic Data	ECOLOGICAL	Ecological Indices	Ecological Values	
Short		○	○	□	○		□	●		○	○	
Medium		●	●	○	●		○	●		●	●	
Long		●	●	●	●		●	●		●	●	
TOTAL		●	●	●	●		●	●		●	●	

○ unavailable but can be gathered

● available

□ unavailable but can be estimated or deduced

Figure 7.3. The availability of data in the short, medium, and long term for the application of the proposed simple version of the framework of the landscape model in the northwestern coastal region of Egypt.

The three identified groups of attributes (political, socio-economic/cultural and ecological) may be dealt with in a time-scheduled framework (Figure 7.4.). This framework takes into consideration both the availability of data and information and the relative importance of the role of the selected attributes in the process of landscape planning in the western Mediterranean coastal land of Egypt. It is formed of three time phases covering

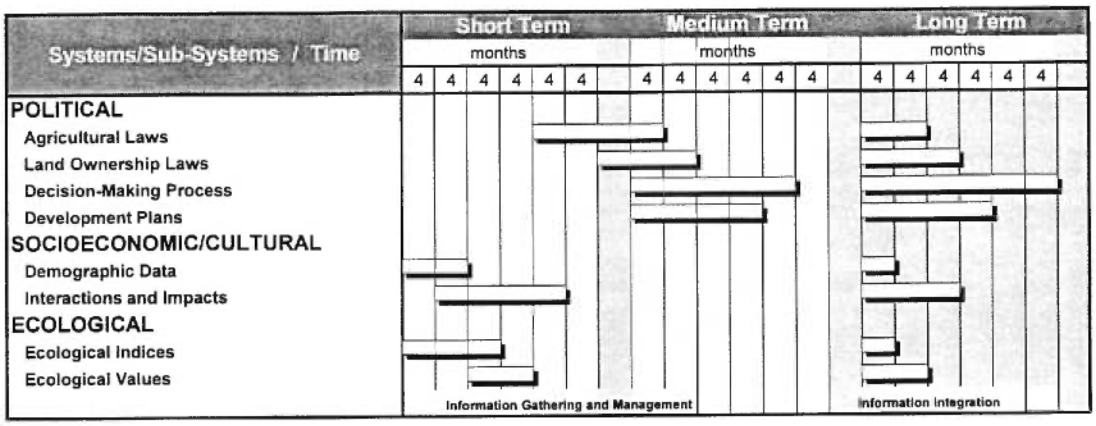

Figure 7.4. Time schedule for the application of the simple version of the framework of the new data input in the northwestern coastal landscape of Egypt.

the analysis procedure. In the first phase, data gathering is to be achieved. Obviously, collection of data on the ecological attributes can be completed in the first phase, since these data are either readily available in the literature and in the present study, or can be easily estimated. The data and information on the socioeconomic/cultural attributes may be obtained later on during the same phase. The information on the political attributes may not be readily available or may be difficult to obtain. Its collection may be extended throughout the second phase. By the end of the second phase, the collection of data and information should be completed. In the third phase the data and information may then be statistically analyzed.

The following chapter provides conclusions of relevance to landscape ecological concepts, the techniques applied in landscape analysis, and the drawbacks and the merits of the idea of comprehensive analysis for developing a landscape planning model for the study area. It also extends some recommendations addressed to scientists, planners, and decision-makers to make use of landscape ecology in future development of the western Mediterranean coastal region of Egypt.

Chapter VIII: Conclusions and Recommendations

The procedure adopted to carry out the present study followed sequential steps. Each step builds upon the preceding ones, and leads to the following step. The study started off by defining the specific objectives and the hypotheses in the form of questions to be answered. One of the main objectives was to explore the possibility of developing a framework for a landscape-planning model for the study area that would be useful in proposing alternative land use plans to the decision-makers. In order to realize these objectives the landscape concepts were reviewed and tested for their applicability in modeling the landscape of the study area. This was achieved by collecting information about changes in landscape attributes during the last few decades, and explaining the landscape ecological concepts in view of these changes. Remote sensing and GIS techniques were applied in generating and organizing this information. The significance of changes and the relationships between attributes were tested by statistical treatments and multivariate analyses that provided guidance of notable value to developing the framework of the landscape-planning model. The final step in the study built upon the concepts of landscape ecology (mainly the concept of holism) and the results of monitoring changes in landscape attributes. This resulted in proposing a framework for a model of landscape planning.

The lessons learned from this endeavor are manifold, and the experience gained furnishes an adequate background to make conclusions and to extend recommendations that may be useful in formulating landscape management plans by decision-makers in the Egyptian deserts. Some of these conclusions and recommendations are based on intuition; these are of general nature and apply to the whole western Mediterranean region of Egypt. Other conclusions and recommendations are based on the information collected and analyzed in this treatise; these are more specific to the pilot study area (Burg El-Arab - El-Hammam area) and other areas of similar ecological and socioeconomic characteristics:

1. The present study is an endeavor that may be considered unique to the western Mediterranean region and indeed to other desert areas of Egypt (e.g. Sinai, the New Valley and Toshka in southwestern desert, and the Red Sea coastal region). These areas represent new axes for socioeconomic development in the Egyptian policy. This endeavor is unique in its approach of landscape analysis, which involved changes in relevant ecological, visual and socioeconomic attributes. These changes occurred during a period between the time when traditional lifestyle and vernacular patterns of land use/land cover were dominating the landscape, and the present time in which intensive irrigated agriculture and construction of summer resorts invaded the region. Besides, it demonstrates a novelty in its capacity to integrate different data types and categories. However, it is by no means as perfect an achievement as it was hoped for. This may be attributed to lack of consideration of some attributes, and lack of in-depth integration of ecological, visual and socioeconomic variables. The main constraint is the unavailability of necessary information (mainly socioeconomic and sociopolitical attributes), or due to inaccessible means of survey. But, an example is set for future landscape analysis in the Egyptian deserts, that is worthy of pursuing and extrapolating.

2. There is strong emphasis in the proposed model on utilizing the application of statistical and multivariate analyses in assessing the relative importance of different landscape attributes, and categorizing them according to the preference of being considered by the model. Besides, these analyses provide the possibility of expressing the attributes of close similarity by one index instead of dealing with each one separately in the model. The net benefit of this application is the simplification of comprehensive landscape analysis that calls for new information input.

3. Comprehensive models for landscape analysis (applied in the present study for generating new information input whenever needed) are being built and are in operational use, although some need refinement. For example the cause-effect relationships associated with partial or sub-models are often the work of a single discipline, which results in a significant amount of biased research. Hence their usefulness is limited, and their effective integration with other models is problematic

for a complete modeling system. The requirements for successful comprehensive landscape analysis in Egypt may be summarized in the following three main points:

a) Resistance to the concept and the process must be anticipated and taken into account when initiating and developing comprehensive landscape analysis models. A carefully formulated strategy and deliberate tactics are required. Item by item, information and analysis must be made useful to decision-makers. Their self-interests are to be deliberately served, with the further purpose of eventually associating them with the planning process and staff.

b) There will have to be institutional changes for real-world acceptance and use. The institutions are required to cooperate in providing estimates of their needs, their expectations of the future, and their explanation of the present. If full-scale cooperation cannot be hoped for, at the least, in addition to the information standards, there should be an official "estimate of the future" against which the governmental agencies could cast their requests. It can be presented as low, expected and high estimates, and could go out at least as far as the year 2050.

c) Integration of elements essential in comprehensive landscape analysis does not come easily. Biological and socioeconomic bases for cooperation develop slowly and often painfully. Coordination implies less selfishness, less egocentrism, willingness to work with others. Not only coordination but also close synthesis is required. Comprehensive analysis presupposes and requires that rationality triumph over irrationality, order over disorder, constructive hope over discouragement and fatalism, action over inaction. It requires extra energy.

In addition, the following set of recommendations which apply to the present case study, are addressed by Alden and Morgan (1974) to those interested, concerned about and committed to comprehensive regional landscape planning:

a) View regional planning as a particular type of national planning, and develop it within a national planning context.

b) Develop comprehensive models for landscape analysis with an awareness of its limitations, and with a concern to elucidate its specific contributions to the national planning process.

c) Develop comprehensive models for landscape analysis with sensitivity to the degree to which it is a substitute for and can be substituted by other types of analysis.

d) Develop comprehensive models for landscape analysis without those forms of organizational and individual commitment, which inhibit deeply penetrated evaluations of its usefulness.

4. The two approaches of multivariate analysis (the "principal component ordination" and "clustering") applied in the present study represent an attempt towards revealing the intricate relationships between landscape attributes. Although this attempt was limited due to shortage of data and information about some attributes, the results of application of these two approaches in the present study provided encouraging evidences of the usefulness of multivariate analysis in future applications to landscape studies. Such analysis can demonstrate the possibility of integrating a group of attributes that are seemingly of different nature (e.g. ecological, visual, social), and may identify which of these attributes is more related to attributes of a different group. For example, in the present study, the application of the ordination and clustering techniques indicated that some visual attributes were related to ecological attributes more than to other visual attributes. Also, the application of some statistical methods in the present study demonstrated the usefulness of such application as a complementary step to landscape analysis. Although the objective of this application was to evaluate attribute variability and relationships, it demonstrated the possibility of comparing the attributes according to their relative importance in landscape analysis.

5. The proposed framework of the landscape-planning model is formed of four main components. It starts with the definition of goals and objectives and ends by the implementation of the developed landscape plan. This framework takes into

consideration the main factors affecting landscape structure and dynamics, the main concepts of landscape ecology with respect to specific characteristics of the designated arid coastal landscape, and the merits of the applied statistical tests and the techniques of remote sensing and GIS. There are two important characteristics of this model framework that have been rarely considered by landscape-planning models. The first characteristic is that it includes two basic crosscutting components, which insure local participation and capacity building at all model phases. The second characteristic is that includes a component, which offers the option of making use of new data and information input whenever needed through an iterative process. For generating such data and information input, a hybrid approach is recommended, which keeps the merits of comprehensive analysis, and in the meantime utilizes the available information at the time of implementing the landscape-planning model.

6. The capabilities of expert systems could be utilized in future landscape research in the study area. These are computer systems that advise on or help solve real-world problems, which would normally require a human expert's interpretation. Such systems work through problems using a computer model of expert human reasoning. Thus, they are designed to reach the same conclusions, as human expert would be expected to reach if faced with a comparable problem. Generally, there are areas where Geographic Information Systems (GIS) are expected to benefit from the application of expert system technology. Geographic data input is one area where expert systems can be used to extract features from imagery, exploit the potential of automatic scanning of manuscript maps, manage the editing of geographic data at the same time data are being captured, and assess the quality of data being entered into the system (Coulson *et al*, 1991; Yazdani, 1993). Expert systems may be used to exploit knowledge about a user query and the GIS itself in order to speed the search through very large spatial databases. Development of intelligent user interfaces will make GIS responsive to user needs because the users will no longer have to become an expert in the use of GIS in addition to their own field of specialization (Coulson *et al*, 1991).

7. The development of a policy of landscape management usually goes through one of three main trends (Rust and Illenberger, 1996):

   a) The "don't-care, free-for-all" trend of no one knows what goes on, no one cares, and when anybody can proceed with impunity with any scheme.

   b) The "hands-off, nothing-is-permitted" trend of the sinking realization that severe environmental damage is being done but not enough is known to understand why. Enforcing such a policy is usually very difficult, if not downright impossible, in the face of limited scientific knowledge, ponderous bureaucratic procedures, economic pressures and political machinations.

   c) The third trend of striking a common-sense balance between conservation and utilization. This signals that a sufficient scientific data base is available to justify specific control procedures, and that the actual process of management is based on support by informed public.

Conceivably, it is wise to adopt the third trend. But this calls for further action in the western Mediterranean region of Egypt, on the side of research workers, planners and land users, in order to be able to develop land use strategies that insure a sustainable level of production and which keep a high degree of compatibility between ecological, technological, visual and sociological variables. The finest landscapes result from land use which recognizes the value of land for shelter as well as for food, for wildlife as well as for man, and for visual pleasure as well as for economic needs (Crowe, 1963).

Besides it is important to note that a strategy of integrated land use systems is more supportive of subsistence economy and may provide a more adequate base for market economy than individual land use systems. Therefore an array of production systems (e.g. rangeland system, rain-fed cropping systems, rain-fed orchards systems, local industry systems) should be encouraged and integrated with the irrigated agriculture system. This integration would be particularly useful in furnishing supplemental feed for grazing animals by cultivating pasture crops in the irrigated area, especially during the drought period (June to September) and at the start of the growing season (October to December). The natural vegetation would then have an ample opportunity to regenerate and become available to grazing animals in greater phytomass during the rest of the year. Also, the herders and the animals may be saved the difficulties of traveling to remote areas (e.g. Nile Delta) every year for supplemental feed, and the risk of introducing exogenous animal diseases to the western Mediterranean region may be avoided.

8. The discipline of landscape ecology can provide a basis for coherent designing of future habitat creation and rational land use strategies in the Egyptian deserts (new lands). It gives an opportunity to understand the landscape by combining the different interacting factors that contribute in shaping its form. More information within the context of the concepts of landscape ecology would be valuable for better integration of ecological, aesthetic, political, social and economic attributes. In particular, a method of quantifying the changes in the pattern of the arid landscape of the study area is needed. For example, a new shape index needs to be developed including the aspect of patch interior as well as the aspect of complexity of the perimeter.

9. Considering the ecological attributes, the results of landscape analysis in the present study suggest that top priority should be given to studying the patterns for protection, with no known substitute for their ecological benefits. These are assumed to be a few large natural vegetation patches, wide vegetated corridors protecting water courses, connectivity for movement of key species among large patches and small patches, and corridors providing heterogeneous bits of nature throughout developed areas. In this context, Forman (1996), considering ecological attributes, provides a landscape model for land use planning:

> *"...in addition to maintaining heterogeneity to satisfy both rarity and diversity objectives, several additional desiderata can be established with respect to landscape's patches. Patches should vary in size so that some are large enough to suit interior species and act as sources of colonization, whilst smaller ones can serve as stepping stones. With respect to shape, a generally isodiametric form will provide a large interior area, but some lobes will assist*

dispersal to surrounding areas and convoluted boundaries will experience higher usage by wildlife."

However, these guidelines deal only with ecological attributes and need to be integrated with aesthetic, political, social and economic attributes.

10. Visual assessments in particular need to be taken into consideration by the Egyptian governmental agencies in development strategies that involve outstanding visual values. The western Mediterranean region as well as other area of scenic attraction (e.g. Sinai and the Red Sea coastal land) is economically dependent upon tourist trade. In this case, the identification, description and analysis of the visual characteristics are important steps in understanding how these development strategies may affect such characteristics. Although ecological arguments provide the most satisfying and fundamental basis on which to plan new landscapes, it is evident that, in practice, programs should be justified in terms of their aesthetic potential and be implemented by professionals whose principal training is in the discipline of landscape planning.

    Furthermore, the present study used innovative methods in analyzing the visual resources of the selected arid landscape using remotely sensed data and satellite image processing. Those were integrated with different and varied data types in a Geographic Information System This attempt represents an example of what can be done in a more comprehensive analysis of such an incommensurable resource of the arid coasts.

11. Traditional environmental knowledge, as an inmate resource to manage the vernacular landscape, parallels the scientific disciplines of ecology and environmental studies (Morin-Labatut and Akhtar, 1992). For example, the relatively small and thinly spread over indigenous population of the study area has been able to maintain a prosperous livestock industry that represents a notable proportion of Egypt's wealth in animal resources. An overall understanding of the history and influential factors of landscape is essential before an attempt is made to alter it by

adding new uses and greater densities. The wise management of natural and agricultural landscapes is also essential for economic planning and development.

However, decisions of development policy in the western Mediterranean region of Egypt, have often been taken by distant government authorities, with the result that local residents are losing control and eventually interest in the quality of their living environment. Such a situation calls for a revival of vernacularism - not a simplistic return to the past- but a blend of modern planning functions with the concerns and lifestyles of local inhabitants. This is strongly emphasized in the framework of landscape-planning model proposed by the present study. The outcome is a landscape that reflects values, supports social structure, and is adaptive to change.

In brief, indigenous conditions and realities should be taken into consideration in any future development plans. Instead of imposing highly developed capital investment in industrial and agricultural systems which may not be compatible with the ecological and sociological variables, development should consider small scale agriculture, rural cottage industries, use of local material, simple erosion control, innovative irrigation technologies, rain water harvesting techniques, and sources of energy based on indigenous renewable resources (e.g. biogas and solar energy).

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