5 REGIONAL PART

5.1 Landscape-ecological analysis

5.1.1 Geological conditions

The research territory is bordered on all sides by hills and mountain ranges, composed mainly of schist, genesis and granitic rocks in the north, and a sequence of unmetamorphosed and slightly metamorphosed sedimentary rocks of palaeozoic and precambrian age in the southeast and north direction. The presence of lacustrine sediments of probable pleistocene age within the valley indicates the site of a former lake which may have resulted from the damming of the Bagmati River System by the uprising "Mahabharat Lake" to the south (Hagen, 1969, Nautiyal and Sharma, 1966). It is, therefore, suggested th at the rise of this Mahabharat Mountain completely blocked the flowing rivers from the Himalaya, thus forming a beautiful valley which dried up about 1-2 million years ago. As a matter of fact, the basin was filled by detritus derived from the bordering hills, especially from the north where crystalline rock such as granite and gneiss predominate.

Distribution of the geological units

According to Binnie and Partner (1973), the geological units of the planned territory are:

- Lake sediments – delta front or channel deposit;
- Lake sediments – predominantly granular sediments;
- Lake sediments (undifferentiated), river gravel and talus and
- Chitlang formation consisting of phyllites, limestones and shales.

However, the fluvial and lacustrine sediments distributed in this regiona are divided into four stratigraphic units. They are: Gokarna Formation, Thimi Formation, Patan Formation, and Lower Terrace Deposit (Yoshida & Igarashi, 1984). The following table shows the stratigraphy of the lacustrine to fluvial sediments distributed in the planned territory.

Tab. 1: Stratigraphy of the lacustrine to fluvial sediments

Age	**Stratigraphic unit**	**Geomorphic surface**	**Radimetric ages of fossils**	**Relative height of the fill top**
Holocene	Recent flood plain deposit			5-10 m above the recent flood plain
Pleistocene	Patan Formation	Patan	11.000-19.000 B.P.	20-50 m above the Bagmati River Bed
	Thimi Formation	Thimi	24.000-28.000 B.P.	50-80 m above the BRB
	Gokarna Formation	Gokarna	28.000-30.000 B.P.	80-120 m above the BRB

The Gokarna Formation is a fluvio-lacustrine deposit in the north of Kathmandu (see Table 1). It consists of laminated arkosic sand, silty clay and peat. The thickness of the Gokarna formation is more than 21 m. The Thimi Formation is distributed mainly at Pasupatinath, and Tribhuvan airport and it consists of fluvio-lacustrine sediments such as sand, silt, clay, peat and gravel. The Patan Formation is also similar to the Thimi Formation, except its relative height of the fill top from the Bagmati River Bed (i.e. 50-80 m) and radimetric ages. It is widely distributed around Kathmandu City and along the stream of the Bagmati River (Igarashi, 1984). The Lower Terrace Deposits are widely distributed along the Bamati River and its tributaries. They consist of mainly micaceous sand and pebble to granular gravels. The surface of the terrace is 5 to 15 m above the recent flood plain. As a matter of fact, the texture of the sediments also differs from place to place. The coarse-grained sediments including gravels mainly occur around the margin of the valley. They are generally composed of gravels of variable size with a sand/silt and clay matrix. Near the foothills the sediments are finer, whereas towards the center a thick layer of clay is interbedded with coarse-grained sediments. For the purpose of interpretation and evaluation of the territory, a synthetic geological unit (Map 1) of Kathmandu has been prepared. This synthetic map not only shows the distribution of the different stratigraphic units, but also clearly delineates the different types of sediments present in this planned territory. The map shows that most of the area is underlined by a thick deposit of clay which may contain occasional sand lenses and small artesian flows present at depth in different places. At the same time, there is also a thick layer of sand with clay lenses varying in thickness over a short distance. In some cases, the clay immediately beneath the surface sand is thicker or the sediments in some locations may contain alternations of clay and sand.

Uses of the geological materials

Basically, the research territory is provided with large granular sediments including gravels, sands and clay and fine sediments such as Kalimati clay of Nautyal and Sharma. Besides these granular sediments, other mineral resources such as peat, marbles and inflammable gases are also noticed. Mostly these granular sediments are used for building purposes, whereas the fine sediments (i. e. Kalimati clay) are used as an important fertilizer in all parts of the flood (dol) and tar (old alluvium) areas.

Environmental impacts

The major rivers of the Kathmandu, especially the Bagmati, Bishnumati and Dhobikhola, have a huge accumulation of the granular sediments (i. e. sands). They are generally broad and wide. Rapid exploitation of these resources for building purposes has created a profound visual effect on the local environment. Most of the built-up areas along the river banks are greatly threatened due to the haphazard and uncontrolled excavation of sand particles. Besides this visual impact, the riverine vegetation (i. e. grasses and small shrubs) have also lost the basis of their existence. In addition to these impacts, there is also a great potential danger of water pollution as a result of the oil leakage in the river bed from heavy vehicles. Apart from these impacts, a large number of brick factories have been established. These factories not only heavily exploited the fine sediments (clay) but also destroyed the landscape and the fertility of the soil to a great extent.

5.1.2 Geomorphological conditions

Geomorphological units

The geomorphological condition of the research territory, as a result of the influence between the exogenous and endogenous power, strongly determinate not only the characteristics of other abiotic components, e. g. angle of the slope, soil etc. but the land use possibilities, too. The general characteristics of the geomorphology of the planned territory have been described by many authors (H. Boesch, 1968, 1972, 1974, H. Yamanaka, 1982, F. Yonochi, 1973, U.M. Malla, 1971, LRMP, 1984). On the basis of these articles it is possible to say that the geological development of the territory is characterized by the formation of the special stratigraphical units with corresponding geomorphic surface (see Table 1). The geomorphological map further shows that the territory has a very typical geomorphological structure which consists of a system of river terraces (recent flood plain and lower terrace surfaces, and ancient or higher river terraces including terrace edges). The recent flood plain and lower terrace surface are locally known as ”Dols”, whereas the ancient river terraces are called ”Tars”. The geomorphological map of Kathmandu City has been prepared after consultation and interpretation of the topographical map (Binnie and Partner, 1973, scale 1:10,000), field observation and after the study of the available literature. The geomorphological map includes the following geomorphological units:

1. River channel and sand bars: This occupies a small area. However, this units plays an important role from the ecological point of view. The relief is level (less than 1°). The channel and sand bars have mostly micaceous sand. The drainage is imperfect. The ground water table lies within 1.20 m of the surface. The most dominant soils are psamments and ustifluvents. At present, this unit is largely used for sand excavation for building purposes.

2. Alluvial plains without man-made terraces: This occupies the greater surface of the study area. It includes parts of the flood plain which is adjacent to the river. This unit is also flooded occasionally. The relief is level (less than 1°). These alluvial plains consist of clay and some sand lens, gravel and sand above clay or alternation of sand and clay. The drainage varies from imperfect to moderate with the ground water table lying in 1.20<m within surface during the monsoon period. The most dominant soil of this unit is the fluvaquent. The present land use is characterized by the presence of non-terraced, well irrigated arable land and residential units with moderately good and medium settlement quality.

3. Lower river terraces without man-made terraces: This occupies a small area in the central part of Kathmandu City and it lies 5-15<m above the recent flood plain. The relief is level (less than 3°). The territory is characterized by the presence of sand and clay. The drainage varies from imperfect to moderate with the ground water table at 1.20<m within surface during the monsoon. The most dominant soil is haplaquepts. The present land use is characterized by the presence of institutions and residences with medium settlement quality. Some non-terraced seasonal irrigated arable land is also found in some parts of the non-built-up areas.

4. Lower river terraces with man-made terraces: They are widely distributed along the rivers Bagmati, Bishnumati and Dhobikhola and lie 5-15<m above the recent flood plain. The relief is level (less than 3°). They are built mainly from micaceous sand and pebble to granular gravel. The drainage varies from imperfect to moderate. The most dominant soils are haplaquents and partly the haplaquepts. The present land use is characterized mainly by the presence of well irrigated arable land (terraced) and partly by seasonally irrigated land.

5. Terrace edge: The contact or transition zone between the recent flood plain (dols) and the ancient river terrace (tars) is known as the terrace edge. This unit is very small but very important from the landscape-ecological point of view. It is one of the very typical and most significant geomorphological units for the creation of the landscape scenery. The slope of the terrace edge varies from 3° to more than 25° . This unit is best developed in those places where gravel layers predominate. It is represented by gneiss, mica, schist and sandstone. The drainage varies from moderately good to well. The ground water table is more than 1.50<m deep. The dominant soils are dystrochrepts and ustorthens. Previously, this unit was mostly covered by large size trees, medium size shrubs and other greenery elements (i. e. grasses and weeds). At present, the terrace edge is mainly occupied by the new residences and only a few steep slopes are covered by forest, shrubs and unirrigated arable land.

6. Non-dissected ancient river terraces without man-made terraces: This area occupies the largest part of the study area. The relative height of the patan geomorphological fill top plain ranges from 20<m to 50<m above the Bagmati River bed. This unit consists of fluvio-lacustrine sediment with an alternation of sand and clay, gravel and sand etc. The drainage varies from imperfect to well. However, the drainage is influenced by the texture and land use. The ground water table is deep. The dominant soils are haplaquepts and ustochrepts and partly rhodustalfs. The present day land use is characterized by the presence of residential units with varying settlement quality, institutional, non-terraced season irrigated land and non-terraced unirrigated arable land.

7. Non-dissected ancient river terraces with man-made terraces: This unit occupies a very small part of the ancient river terrace. It is close to the north of the study area. The characteristics and the properties of this unit are similar to the non-dissected ancient river terraces without man-made terraces. However, the relief is less than 3° and the drainage is relatively good.

8. Dissected ancient river terraces without man-made terraces: It represents a small area and lies at the higher altitude of the river terraces (50-80<m above the Bagmati River bed). The Thimi geomorphological surface is located in this area. The sediments are chiefly gravel and sand above clay, an alternation of sand and clay etc. The relief is level and less than 3°. Because of the light-textured parent material and the presence of the highly branched terrace edges, the degree of dissection is very high (e.g. airport and Pashapatinath). The texture of the soil is normally coarser than non-dissected tar. The drainage is imperfect to well. The ground water table is very deep. The most dominant soil is rhodustalf. At

present, the land is used for transportation purposes (airport), industry, agriculture (seasonal irrigation), residential and religious (e. g. Pashupatinath) purposes.

9. Dissected ancient river terraces with man-made terraces: Most of the characteristics of this unit are similar to the above mentioned geomorphological unit. However, the relative height of this unit corresponds to the Patan geomorphic formation. The most dominant soil of this unit is ustochrept. This unit is also characterized by the presence of seasonal irrigated and unirrigated arable land.

10. Moderately to steeply sloping mountaneous terrain: This unit is small and lies at a higher altitude (e. g. Swayambhunath forest above Balaju). It corresponds to the Gokarna geomorphic formation. The relative height of the fill top plain ranges from 80-120<m (i.e. above the Bagmati River bed). It consists of limestone and sandstone. The slopes are very steep and the angle of slope is more than 25°. It is well drained. The ground water table is very deep. The most dominant soils are dystrochrepts and haplumbrepts. The present land use consists of forest and monuments (e. g. Swayambhunath).

Slope condition

The angle of slope was evaluated on the topographic surface at each point of slope curve. The angle of slope was prepared by using the topographical map with an equidistance of 5<m between neighboring contours. The slopes can be simply interpreted as an assumption for the movement of water and materials along the slope and described as energy of relief. The categories of slope mapped for landscape-ecological planning are the following tab. 2:

Tab. 2: Angle of slope in degrees, relief energy, slope classes

	Angle of slope in degrees	**Relief energy**	**Slope classes**
1	0.0 – 1°	assumed no relief energy	level sloping
2	1.1 – 3°	negligible relief energy	nearly level sloping
3	3.1 – 7°	small relief energy	gently sloping
4	7.1 – 12°	medium relief energy	moderate sloping
5	12.1 – 17°	great relief energy	nearly steep sloping
6	17.1 – 25°	nearly very great	steeply sloping
7	relief energy above 25°	very great relief energy	very steep

5.1.3 Soil conditions

The soil pattern in the research territory is strongly related to the geomorphological features, geological structure, angle of the slopes, climatological condition, local hydrology, etc. Apart from the natural conditions, the man-made factors such as artificial irrigation, drainage and sewerage system are considered to be some of the most important factors for the development of the major soil groups, i. e. entisol, inceptisol and alfisol in the different geomorphological units. The soil map so far prepared (FAO, 1974) is rather simple and gives only a general concept for each delineated soil unit. A lot of relevant and detailed information has been found in the Land System Report (LRMP, 1986). However, the lack of the analytical soil map within the system itself is still a great problem for delineating the particular soil units in the territory. It is, therefore, suggested that a more detailed soil map should be prepared by the Nepalese soil scientists for future planning processes. In order to provide better landscape-ecological planning, the preparation of a separate analytical soil map is an urgent task. Based upon this fact, a potential soil map in the different geomorphological units of the planned territory has been prepared. Moreover, the potential soil map has been prepared after consultation of the following available literature and maps:

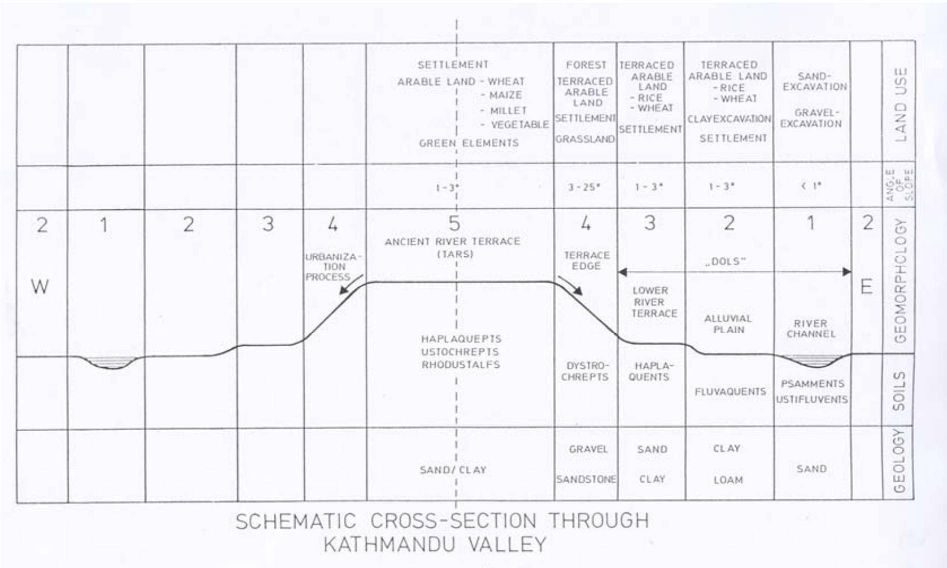
- LRMP (1985) Land System Report;
- FAO (1979) Soil Survey of Bagmati and Narayani;
- FAO (1974) Reconnaissance Soil map (scale 1:100,000) of Kathmandu Valley;
- Department of Housing: Building and Physical Planning (1969); Irrigation classification map of the Kathmandu Valley;
- Brock (1984): A soil survey of the Kathmandu Valley;
- Soil Conservation Service, U.S. Department of Agriculture (1975). Soil taxonomy, a basic system of soil classification for making and interpreting soil surveys;
- Geomorphological map.

For convenience, the following table and Fig. 4 shows the distribution of the most important soil types present in different land form/geomorphological units of the study area.

Tab. 3: Distribution of the soil types in connection to the geomorphological units and land use

Soil	Soil type Unit	Geomorphological Unit	Land use (dominant)
1.	Psamments and Ustifluvents	River channel and sand bars	(i) Excavation of sand and gravel
2.	Fluvaquents (ii) excavation of clay for bricks	Alluvial plains	(i) rice production
3.	Haplaquents Lower river terraces	Alluvial plains (ii) built-up areas	(i) rice and wheat prod.
4.	Haplaquepts Lower river terraces Non-dissected and dissected ancient river terraces	Alluvial plains (ii) built-up areas	(i) rice and wheat prod.
5.	Dystrochrepts and Ustochrepts sloping mountainous terrain	Terrace edges Moderately to steeply (iii) forest	(i) wheat+rice production (ii) built-up areas
6.	Haplaquepts and Ustochrepts river terraces	Non-dissected and dissected ancient	(i) wheat+rice production (ii) built-up areas
7.	Ustochrepts dissected ancient river terraces	Non-dissected and (ii) wheat, rice and vegetable production	(i) built-up areas
8.	Rhodustalfs river terraces (ii) transportation	Dissected ancient fruit production	(i) maize, millet and
9.	Dystrochrepts and Hamplumbrepts sloping mountainous terrain	Terrace edges Moderately to steeply (iii) built-up areas (iv) upland crops	(i) forest (ii) monument

Fig. 5



The general characteristics of the soils present in the territory are briefly discussed below.

Psamments

These entisols are developed on river channel and sand bars (geomorphological unit 1). The dominant slopes are less than 1° . These soils are characterized by their grey, sandy loam to loam surface horizon overlaying a thick sandy substratum, usually less than 20 cm from the surface. The drainage is imperfect. However, the drainage of the soil is affected by the relative relief of the site and the textures. These soils are extensively used for building purposes.

Ustifluvents

They are the common entisol soils occupying river channel and sand bars. They are also found in the flood plains of rivers and streams (geomorphological unit 2). Most of the rivers in a depositional stage are characterized by the presence of the ustifluvents. Sediment deposition is of sufficient quantity. They are coarse textured, have high permeability and, except during actual flooding, they are well drained (LRMP, 1985). Due to the presence of surface textures of sandy loam to loamy sands, there is a considerable risk of wind erosion, especially from February to May when soils are drained out and winds are strong. These soils are important sources of sands and gravel for construction purposes. Moreover, their appearance along the river banks have played a significant role for rice cultivation. The water table is usually deep due to their ustic moisture regime. There is a considerable risk of the flood. These soils are also used for the transportation corridor. Natural vegetation present in this soil unit are chiefly grasses and xerophytic plants.

Fluvaquents

These entisols are particularly distributed in the alluvial plains without man-made terraces (geomorphological unit 2). They are more or less similar to ustifluvents, except that they are imperfectly to poorly drained. They are also known as the wet soil of floods – most of the sediments are deposited under changing currents and shifting channels. The slope is nearly level. The texture of the soil ranges from coarse to medium. The presence of highly organic compounds makes the soil very fertile. A sufficient quantity of water is also available for irrigating the paddy fields. Among the important hazards are river bank cutting and river channel overflow onto crop lands. Increased flooding during the rainy season could destroy them. However, reclamation of damaged land is a constant occupation of farmers (LRMP, 1985). Natural vegetation developed in this soil unit are mainly forests of water-tolerant trees.

Haplaquents

These aquic soils are also the dominant soil in alluvial plains without man-made terraces, lower river terraces without man-made terraces and lower river terraces with man-made terraces (geomorphological units 2, 3 and 4). Haplaquents include grey, stratified, sandy loams to sands often with gravelly layers at a shallow depth. The drainage is imperfect. These soils are extensive in upland depressions and are used for cultivating several crops such as rice, wheat and some vegetables.

Haplaquepts

Haplaquepts are the extensive soils of alluvial plains without man-made terraces, lower river terraces without man-made terraces, lower river terraces with man-made terraces, non-dissected ancient river terraces (tars) without man-made terraces, non-dissected ancient river terraces with man-made terraces, dissected ancient river terraces without man-made terraces (geomorphological units 2, 7, 4, 6, 7 and 8). However, the texture of the soil in the dissected ancient river terraces is usually coarser than that of non-dissected ancient river terraces. Normally, the texture ranges from loamy sand to heavy clay. The drainage is imperfect to poor. The soil is strongly affected by water for at least part of the year and shows the aquic moisture regime. Artificial drainage systems have played a significant role for the development of this type of soil. Moreover, these soils are found in combination of other soils such as ustochrepts. These soils are primarily used for a variety of agricultural production, such as rice, wheat and potatoes. At present these soils are, however, occupied by heavy settlement.

Dystrochrepts

Dystrochrepts are commonly found at the terrace edges (geomorphological unit 5). However, they are also reported in the dissected and non-dissected tars, including moderately to steeply sloping mountain terrain (geomorphological unit 10). Usually they occur at steep slopes of the above mentioned geomorphological units and are mostly stony. They are also known to be the common soils of gneiss, mica, schist and non-calcareous sandstone, having a strong leaching regime. The soil is well drained and usually important for dry farming (wheat and maize). However, irrigation schemes and fertilizer input will greatly favor the rice cultivation. Natural vegetation in these soils are mostly deciduous hardwood trees.

Ustorthents

This is a typical soil of the heavily eroded terraces and dissected ancient river terraces (geomorphological units 5, 9 and 10). These soils are also used to describe eroded sites where diagnostic soil horizons have been removed. According to some soil scientist, ustorthents are found on recent slide scars and slopes greater than 35°. These soils are intimately associated with many other soil types such as dystrochrepts, rhodustalfs, haplumbrepts as well as exposed bed rock. The drainage is perfect. The soil shows ustic moisture regime and the ground water table is greater than 150<cm. Natural vegetation consists of scattered grasses with many xerophytic shrubs.

Rhodustalfs

This alfisol is also widely distributed in the non-dissected ancient river terraces without man-made terraces, non-dissected ancient river terraces with man-made terraces, and dissected ancient river terraces (geomorphological units 6, 7, 8, and 9). It represents pedogenetically mature soil and the texture ranges from fine loamy to clay texture. They are often unirrigable due to their high topographical position. The soil is well drained but shows relatively low permeability. This soil is mainly suitable for some maize, millet and fruit production. During the rainy season sheet and gully erosion are also noticed. Natural vegetation, if present, are mostly grasses, scattered woody shrubs and some trees.

Ustochrepts

These inceptisols are among the most common soils of non-dissected ancient river terraces and dissected man-made ancient river terraces (geomorphological units 6, 7, 8 and 9). Locally, they are also said to be the soils of the Khet land. These soils are developed on phyllites, schists, quartzites and limestones. They are coarse loamy to loamy textured. Because of the wide range of parent materials, climate and management practices, ustochrepts are quite variable regarding textures, soil structures and drainage. In most cases they are well drained. However, artificial drainage and irrigation systems and heavy settlement etc. have altered the drainage quality, i.e. imperfectly drained. The soil is suitable for rice, wheat and potato cultivation. Natural vegetation in most ustochrepts consists of small grasses and some trees.

Haplumbrepts

These soils are commonly found on steeper slopes of the moderately to steeply sloping mountainous terrain (geomorphological unit 10). When cultivated, soil remains fertile as long as organic matter levels are maintained. This soil is also commonly noticed under high vegetative cover, especially under forest. The drainage is well developed. The texture varies from loam to silty clay loam. The soil shows udic moisture regime. It is locally known as the soil of the Bari land. The soil could be used for wheat and maize production, but it needs adequate soil conservation measures so that fertility could be maintained. Natural vegetation in this soil type consists of mixed forest and some conifer forest.

5.1.4 Hydrological conditions

Problems and prospects

The high and steep mountainous topography coupled with abundantly available surface water makes Nepal a country very rich in water power potential. The rich water potential and the extraordinarily convenient configuration of rivers provide good conditions for cheap energy production as well as prospects for hydroelectric development works. However, the above mentioned facts could not hold equally true insofar as the hydrological conditions of Kathmandu are concerned. The problems is not only related to the exploitation of enough water of satisfactory quality, but many other constraints in connection with water resource development, e. g. finances, organization and capacity (in terms of efficient manpower), have limited the desired development of the city. Despite the fact that many alternative sources of surface and ground water such as springs and streams, direct supply from on-channel dams, many off-channel storage schemes, deep and shallow well schemes, etc. were identified and evaluated and that there has been some information on local hydrological conditions, there still remain many unknown factors about the long term safe yield of many deep and shallow wells, about the water treatment requirements for waters derived from the potential resources. Moreover, the future water demand depends upon the careful planning, management and conservation of these watershed areas, as well as development of many alternatives (deep and shallow wells) around the urban-rural areas of Kathmandu.

Water balance

The water balance of the Kathmandu Valley studied by Binnie and Partner (1973) indicated that within the valley the estimated mean annual precipitation is 1740<mm (68.5<in), of which 877<mm (34.5<in) are lost by evapotranspiration and 863<mm (34.0<in) leave the valley as run-off. An estimated 45<mm were applied as net irrigation and 16<mm diverted for water supply and only 1<mm was consumed. About 20-25% of the annual run-off occurred outside the monsoon season. So a large proportion of this is probably being used for irrigation. Seasonally, the maximum irrigation demand is during the weeks immediately preceding the monsoon, when the supply is at minimum. At this time, virtually all surface flows are used and the effect of irrigation on the average annual run-off is almost a reduction of 5%.

Potential water sources

Kathmandu is drained by only one river – the Bagmati River. In the dry season the amount of water flowing out of the valley is small as few of the tributaries of this river are perennial. Other sources of water include a few springs and underground water. The Bagmati River originates in Vag-dhara at an altitude of 2650 m southeast of Lake Sheo-puri. Two main tributaries, the Nagmati and Sialmati join the Bagmati near Sundarijal. Water is collected in the Sundarijal reservoir and treated water flows by gravity to the Mahankal Chaur service reservoir on the outskirts of Kathmandu. Another main tributary is the Bishnumati River with its origin in Vishnap, south of Sheo-puri at the altitude of 2430<m. Other small tributaries of the Bagmati River are the Dhobi Khola, the Tukucha, the Manohara, etc. Other surface reservoirs such as Balaju, Maharajgang, dams – i.e.

Balkhu Khola, Gokarna Gorage, many schemes such as the Birdhana and the Phorping schemes and a few underground wells are also found in Kathmandu. The main wells situated in this planned territory are the Balaju well and the Bansbori well.

Ground water potential

It is said that the ground water potential of the Kathmandu Valley is limited. Moreover, the aquifer in the Kathmandu Valley is extremely complex, although there have been encouraging results with respect to yield and the proximity to town. Binnie (1973) has suggested two main factors to be considered in accessing the potential of the upper aquifers as a source of water supply: (1) The ability of the site to give useful yields and (2) the ability to maintain these yields for an adequately long period. Apart from many other sources already mentioned in the above paragraphs, the ground water potential for Kathmandu could be categorized into two big groups:

(1) Potential deep well fields, and
(2) Potential shallow water fields.

The optimum program for the development of these potentials is, however, based on the following considerations:

- The relative cost per unit of production of deep and shallow wells, and the relative cost of transmission to existing system elements;
- The water demand and the availability of water from the proposed sources to meet these demands; and
- The distribution system improvements necessitated by the increased water demand and the available supply.

At present, the concerned authorities have given increasing attention to the development of these two schemes because of the fact that the existing resources are not able to meet the full demands of the increasing population. It is assumed that the existing Mahadev Khola supply element will be retired, that the Balaju filtration plant and the Maharajgang treatment plant will be retired and that seven remote run-off stream schemes at Tri-Bhidhara and Birdhara (North-Kathmandu) will be suitably upgraded and utilized solely as rural supply elements.

From the above assumptions it could be concluded that the establishment of deep and shallow water plants would be the most important potential source of water which is relatively economical and feasible as the future water supply for Kathmandu. There are three potential sites for deep well fields, i.e. the Bansbari, the Gokarna and the Balaju well fields. These fields located on the northern aquifer are the most attractive option for development. Among these three deep wells, the Bansbari deep well scheme is considered the most favorable site for development because it is relatively close to the centre of demand and located at a relatively higher elevation. Less is known about the Gokarna site and further development of the Balaju well may be unfavourable since the water is considered to be of relatively poor quality (NSWSSP, 1979).

Besides the above mentioned deep well schemes, shallow well schemes which are proposed in the flood plains of the rivers can also contribute to the future water supply of Kathmandu. Important sites for these schemes in the order of priority are: the Dhoki Khola (north of Ring Road), the Bishnumati Khola, the Bagmati River (near Baudha) and the Manohora River in its upper reaches. Among these schemes, the Dhoki Khola shallow well is quite extensive (Nepal second water supply and sewerage project, 1979). Extraction of water is also easy due to the presence of thick deposit of sands (about 40<m). It is also located closer to the metropolitan area than other shallow wells. Moreover, it was found that the water table in the alluvium of Dhobi Khola would be drawn by only 5<m if 20 mld were extracted each day for 100 days. Furthermore, this aquifer is continuous for many kilometers to the north, east and west of the site (Binnie, 1973). It is, therefore, suggested that the Dhobi Khola scheme be considered the prime candidate among the shallow well alternatives.

The report on potential water surface, second project, 1979, further reads: "In the case of Greater Kathmandu, however, the only alternatives – costly surface water developments – are considered far less attractive than development of ground water sources, in fact so much less attractive as to demand that the unkown factors of ground water development be resolved and efforts directed towards developing these potential resources".

Water quality

The quality of water, particularly for domestic consumption, is a serious environmental concern. Water-borne diseases are rampant. The lack of sufficient water treatment facilities and poorly managed sewerage systems are among the major causes of these health hazards. Because of the poor quality of the water available, there is a frequent incidence of diarrhea, gastritis, typhus and cholera. What is available is polluted at all sites and places, resulting in high morbidity and mortality. Water is highly corrosive and water extracted below 26 m is unpalatable (Binnie, 1973). Water from the deep wells in the center of the valley, where there are old sediments, contains hydrogen sulphide and methane gas. In general, shallow ground water (proposed for the future water development scheme) is fresher and has a lower concentration of chemicals than deep ground water because it has not been in contact with sediments for such longs periods (WSSP, 1979). However, there is a widespread notion that shallow wells produce water of inferior quality to deep wells and that a well must be drilled below at least one impermeable strata in order to provide water of satisfactory quality (WSSP, final report, 1979). The water extracted from the confined aquifers in the central areas of town show a high concentration of other chemicals such as iron and manganese. The results of chemical analysis of ground water further indicated that most characteristics of the wells located outside the central part of the valley are below the "highest desirable level" as listed in International Standards for Drinking Water. So far as the quality of the surface water is concerned, the results obtained are more serious and discouraging.

Many studies found that the surface water is heavily contaminated with more than 70% of bacteria, helminthes and a heavy amount of poisonous chemical compounds. There is also a high risk of contamination of these harmful organisms and chemicals to the treated water due to haphazard leakage of old pipes (distributing pipes) and illegal connections to the distributing networks in different localities. It is, therefore, concluded that the quality of water – either surface or underground – is not free from any contamination. Only properly designed and constructed wells or ground water collection devices are equally capable of producing water of adequate bacteriological quality as are complete water treatment plants for surface water. Water without sufficient measures, such as complete aeration, pH adjustment, filtration, regular chlorine treatment, regular check of leakage and use of high quality materials (i. e. use of stainless steel for wells) will lead to serious health hazards and even to the death of many organisms, including human beings.

Water supply and per capita consumption

The per capita water consumption was estimated to be 80 liters person/day. The probable range of the per capita daily consumption for private connections is from 69<l to 251<l. As a matter of fact, the actual amount of water used by the population is still unknown because of the fact that nearly 60% of water are unaccounted for due to high rate of leakage and illegal connections. However, the Water Supply and Sewage Corporation (WSSC) has calculated about 116<lcd of water for average private connection consumption in Kathmandu. The amount of water supplied is also expected to increase after the implementation of the Decade Plan (1980-1990) (Padco, 1984). Moreover, additional quantities of water from deep and shallow well schemes are expected to meet the peak day demand of 124<mld in the year 1990. At present, the supply of sufficient potable water is well below the satisfactory level. Lack of effective government action in terms of policies, legislation, financial support, operation, management and coordination among the key sectors seems to be one of the greatest barriers to fulfill the demand of the population. According to recent reports (1985) produced in preparation of the third and fourth World Bank financed water supply and sewerage projects, actual levels of water supply service achieved in most of the Town Panchayats fall well below design targets and are generally unsatisfactory. This results from one or more of the following:

- inadequacy of source of water;
- inefficient system capacity or storage;
- ineffective water treatment;
- lack of adequate routine system maintenance;
- age of system (most of the water pipes are very old and the leakage is expected to be very high); etc.

According to one estimate, only a population of about 316,000 people in Kathmandu and Patan is supplied. Furthermore, if we examine the per capita consumption within different localities of Kathmandu, the water supply service is very poor and there is a great diversity in the consumption level of inhabitants residing in the same districts. It is also assumed that the demand for drinking water alone will increase to 10,000,000 gallons per day in the next 25 years; if sewerage systems are installed in the urban centers during that period and if the demand for water supply other than for domestic use is also taken into consideration, utilization of the whole of the valley run-off will be necessary to meet the supply requirements (PDPKV, 1976).

5.1.5 Climatic Conditions

Although the valley of Kathmandu lies lower than 28° N in latitude, it has a climate resembling that of some southern countries of Europe. Kathmandu City with an average elevation of +1350<m lies at an exceptionally favorable altitude in terms of climate.

Temperature

The climate in Kathmandu on the whole is not very different from other cool, temperature regions of the world, but the temperature during the hot season is very pleasant. Moreover, the local temperature condition depends greatly on the degree of exposure to the sun. Generally, the north-facing slopes are cooler than the south-facing slopes. The following table shows the maximum and minimum temperature and rainfall recorded in Kathmandu.

Tab. 4: Temperature and Rainfall of Kathmandu

Month	**Average in centimeters**		**Average monthly total rainfall [mm]**
	Maximum	**Minimum**	
January	16.6	2.2	18
February	19.1	3.3	16
March	23.6	11.6	48
May	27.7	15.5	90
June	27.4	18.9	248
July	27.0	19.9	286
August	27.0	19.6	284
September	25.9	18.1	179
October	24.6	13.4	78
November	21.3	6.9	6
December	18.3	2.1	1

Source: K. Shankar and P.B. Shrestha (1985). "Climate in Nepal", in Nepal, "Natures' Paradise" Ed. Majpuria, White Lotus Co. Ltd., Bangkok, Thailand.

It was recorded that the mean monthly maximum temperature at Kathmandu (altitude 1288 m) occurs in June with 24° C, while the mean monthly minimum temperature occurs in January with 7° C (Climatic Records of Nepal, 1985). There is only occasional frost (abs. min. 2° C), though the territory is located in the cold mountain zone, but the winters are so mild at this elevation that year-round vegetable cultivation is possible.

Rainfall

According to the study of Kathmandu Valley Physical Development (1969), the valley received an average annual rainfall of 3220<mm. The maximum rainfall occurs in summer, especially from June to August. According to a recent study (P.B. Shrestha, 1985), Kathmandu gets about 1346<mm of rain a year. Moreover, Kathmandu having a mountain rim of much lower height on all sides gets less rain. Precipitation is also characterized by a typical regime: approximately 80% of the total annual precipitation falls during mid-June

to early October and the months of least precipitation are November to March. The lack of water and moisture during the dry months is considerable and constitutes the limiting ecological factor for vegetation and cultivation. The following table provides the frequency analysis of 24 hrs precipitation of Kathmandu.

Frequency analysis of 24 Hrs. Precipitation of Kathmandu

Tab. 5: 24 Hrs. Max. Rainfall of the Wettest Month Station – "Kathmandu Airport + Kathmandu Indian Embassy"

Year	Precipitation (P) mm	Year	Precipitation (P) mm
1945	182	**1962**	72
1946	114	**1963**	54
1947	65	**1964**	84
1948	82	**1965**	72
1949	54	**1966**	115
1950	105	**1967**	134
1951	66	**1968**	75
1952	59	**1969**	59
1953	116	**1971**	109
1954	173	**1972**	107
1955	53	**1973**	83
1956	50	**1974**	53
1957	58	**1975**	82
1958	46	**1976**	71
1959	48	**1977**	58
1960	59	**1978**	71
1961	70	**1979**	86

Source: K. Shankar and P.B. Shrestha (1985). "Climate in Nepal", in Nepal, "Natures' Paradise". Ed. Majpuria, White Lotus Co. Ltd., Bangkok, Thailand

Relative humidity

Relative humidity starts decreasing from January and attains its lowest level (55%) in the month of April. It is higher in the morning and decreases towards the evening and the diurnal range is greatest in summer just before the monsoon begins. April and May have a relative humidity below 60%.

Winds

The direction of the wind from January to May is mainly north-west, while during June to December the wind direction is generally north or east.

Pressure

From October to November the station level pressure remains highest and steady. Falling slowly from February onwards, the atmospheric pressure remains lowest during June to July.

5.1.6 Vegetational conditions

Analysis of the present situation

Kathmandu City, which lies in the midland forest of Nepal, is endowed with a rich mixture of surface vegetation. Historical evidence suggests that after the lake drained out of the valley, lush forests were formed. These forests were cleared to open the land for agriculture and settlement purposes and as a result of increasing population growth and uncontrolled urbanization, today this area represents only limited green vegetation in the form of small grasses, herbs, shrubs and trees. Extensive forests have been reduced to isolated stands as a result of the then numerous settlements and extensive farming system. However, the people dwelling around the sub-urban and rural parts of this region have preserved the remaining vegetation of some water courses, steep slopes, agricultural fields, transportation networks, residential areas, religious forests and some other woodlands. The spatial distribution of the general vegetation has been prepared after air photo interpretation and field observation. The territory belongs to the ecological region III F (Dobremez, 1976) and falls under the sub-tropical zone of lower stage extending from 1000 to 15000<m. Usually, a fair account of grasses, dense cover of trees, and the presence of weeds (though economically harmful) have played an important role for the overall ecological balance of the city.

Some special vegetational features

This territory, though small in size, consists of a chaotic mixture of various exotic and endemic varieties of plants. There is also a mixture of tropical elements as represented by bamboos and temperate elements such as oaks. They reveal a distinct difference (exposure-determined) between the southern and northern basin edge. A belt of pinus roxburghii runs along the northern edge (sunny slope), while evergreen deciduous forests reach down into the valley bottom on the southern basin rim (shady slope). According to Hafner (1983), the appearance of frost-sensitive park trees and bushes is characteristic of the climatic nature of the Kathmandu valley. The ”mediterranean” impression is enhanced by the presence of Arundo donax reed, frequently found on the boundary between the dry fields and artificially irrigated farm lands. The particularly evergreen, macchi-like degraded bush forest formations, which stretch like a fur coat over the gully-ridden and soil erosion prone valley slopes, are also an integeral part of this picture. The overall vegetational condition of Kathmandu could be summarized in the following points:

- Small patches of the so-called endemic varieties of plant species, small to large in size, which were originally brought (mostly by natural means) from the nearby forest of Kathmandu valley, i. e. from the forests of Gokarna, Raniban, Sheopuri, Godawari. These species were able to maintain their habitat according to the local climate of the region.
- Additional stands of trees and shrubs serving as a protective barrier (i. e. against flood, erosion etc.) are also found along the Bagmati River courses and its tributaries and in many communicating networks (artificial plantation). Many exotic species such as Eucalyptus globulus, Grevillea robusta, populus deltiodes etc. are found on old residences, particularly in the gardens of Rana palaces and on the major transportation routes, especially Ring Road and Babar Mahal etc., of the city.

- Many species of weeds are of common occurrence, especially on degraded/vacant lands.

Among the general vegetation of the planned territory, many species of weeds occupy a special position. Despite their economic disadvantages such as reduction of soil fertility, decrease in selling value of the land, increase in utilization cost (especially in agriculture) and possible physical injury to a wide range of animals as well as human beings, their role und function (indirect) within the ecosystem could not be neglected by this study. Regmi (1985), however, emphasizes that "it is very heartening to note that many of the abandoned or collapsed houses, monasteries and other wasteland has become the stock nursery or showcase for the sample study of weed flora in Nepal". Because of their habit of intruding, plants like Eupatorium lantana, Rybus, Imperata sps are distorting nature and Kathmandu Valley has become their victim. The weeds of Kathmandu Valley should not always be regarded only in terms of negative aspects. They should, however, be preserved and conserved so that the landscape could be saved from many natural disasters such as erosion, landslide and flood.

Abundance of plant species according to land use

Moreover, these elements could be planted on some transportation corridors and vacant (unused) land of the city. The following species of plants are identified in the present day land use forms of Kathmandu.

Abundance of plant species on arable land, meadows and pastures

The abundance of plant species on the present-day arable land, pastures and meadows is well below the required level. The farmers are able to preserve the remaining isolated trees only to a limited extent. These land use forms are characterized by the presence of many weed plants and the presence of a large quantity of weeds in the arable land has created many problems for the farmers. The following are the dominant species of plants (including some weeds: Albizia lebeck (black siris), vitex negundo (simli), Euphorbia mili (labre Khada phul), Polygonum sps, Artemisia vulgaris (tite pati), cyperus articulatus (mothe), Lathyrus aphoca (wild pea), cannabis sativa (bhang), Cynodon dactylon (dubo), Eupatorium aderophora, Digitaria adscendens, mimosa pudica (sensitive plant), Paspalum flavidum (Banso), oxalis latifolia, Imperata cylindrica (siru), Sciegesbeckia orientalis (kure gandhe), etc.

Abundance of plant species in the settlement and transportation networks

The destruction of the town and surrounding countryside is without parallel. Parks and woods which had not already been destroyed finally fell under the axe to supply wood as fuel. Very little attention has been given to the maintenance of the quality of the extensive residential areas by protecting public and private green areas against the encroachment of buildings and nothing has been done to improve the quality of the environment in the residential areas close to the center. The living environment is becoming less and less attractive as its quality is reduced and there is a lack of green areas. Most of the public places have been converted into barren land. The streets look like that of a ghost town with its ruins. Many beneficiary effects of the vegetation, such as a small-scale beneficiary effect on the climate, the production of oxygen, the filtration of dust particles, a decrease in the noise level, etc. are not sufficiently emphasized by the authorities concerned with these land use forms. The greenery elements available are a few species of endemic and exotic varieties of plants scattered in an unplanned and haphazard fashion. However, the following species of plants are still found in some forms and functions. They are chiefly: Salix babylonica (willow), Ficus religiosa (pipal), Populus deltiodes (Lahre pipal), Eucalyptus camaldutensis (Masala), E. Robusta, Buddleja abiatica (Bhemsen pati), calistemon viminalis (Kalki phool), Duvanta repens (nil Kanda), Mangifera indica (amp, only a few), Phyllanthus emblica (Amala), Prunus persica (aru), Melia Azagarach (bakino) etc. Some species of weeds are: Eupatorium adenophora (Banmara), Urtica parviflora (sishnu), Dicrunopteris glauca (hade unyu), Sciegesbeckia orientalis (kure gandhe), Anchyranthes bidentata (datium), Paspalum floridum (banso), opuntia dilleni (prickly pear), Ageratum conyzoides (gandhe), etc.

Abundance of plant species on river courses

The importance of this territory in relation to the vegetation of water bodies has undergone substantial changes over the centuries. There is also an increasing tendency towards bulding new houses on the river banks of the Bagmati River and its tributaries. As a result of these activities, most of the vegetational cover has been reduced drastically. Its functional role, such as protecting water against pollution, erosion and flood control, river bank cutting and maintenance of the water quality, has been reduced to a great extent. Only a few species of plants, such as Duranta repens, Rosa prununii and some other common weeds, e.g. Ipamea aquatica (swamp cabbage), Eupatorium adenophora (banmara), Hydrilla verticillate (Pani unyu), Bierunopteris glauca (hade unyu), Euqisetum arrensis (kur-kur), are found along the water bodies.

Abundance of plant species in woodland areas

According to some authors (Shakya, 1983), the forest of Nagarjun which makes up the northwestern boundary of Kathmandu Valley consists of 4 types of forest. These forest types are also found in other woodland areas of Kathmandu. They are represented by:

- Dry oak forest;
- Schima Walichii forest;
- Mixed broad-leaved forest;
- Chirpine forest.

Furthermore, a sharp boundary between the forest in moist localities and dry localities can be noticed. The following species constitute the forest of some localities: Alnus nepalensis (utis), Quarcus indica (Katus), Schima Wallichii (Chillaune), Quarcus glauca (Phalant), Prunus cerasiodes (Paiyun), etc. However, the forest of Chirpine Pinus roxburghii requires a relatively dry site or a site where a large amount of precipitation rapidly evaporates or is carried away. The common shrubs are Carex longipes, Ligustrum nepalensis, Mahonia nepalensis, Simlex aspera, onychium Incidium, Assimile, Daphne bholua, Brassaiopsis glomerulata, Rhododendron sps, etc. Apart from the above mentioned general abundance of the plant species, the following details about woodland areas of this planned territory provide a brief account on cover type, abundance of species, crown density and maturity class.

Swayambhunath woodland area

According to the Land Resource Mapping Project (1986), more than 75% of species are of the hardwood type. The dominant species is Pinus roxburghii (Chirpine). Many other tropical mixed hardwoods are also found. The percentage of area covered by these tree crowns is 10-40%. They are mature to over-mature trees and have reached rotation age of saul timber size. The forest is considered to be holy and has been conserved by the local religious people for many years. One of the negative impacts of this forest of lower altitude is the rapid disappearance of plant species due to uncontrolled grazing and illegal felling of trees for fuel by the local inhabitants.

Balaju woodland area

This area lies to the northwest of Kathmandu City. This forest has played a vital role since the remote past. The presence of springs and water reservoirs in this area has attracted hundreds of thousands of people, including tourists from abroad. However, the establishment of the Balaju industrial plant in the vicinity of this forest area will have a lot of negative impact in the near future. The species present in this forest are similar to those of the Swayambhunath woodland forest species. The percentage of the area covered by these tropical mixed hardwoods is in between 40-70% and the species present in this forest area fall in the mature to over-mature class.

Pashupatinath woodland area

One of the oldest religious forests of urban Kathmandu is the forest of the Pashupatinath area. Its importance can be traced far back historical ages. The area covered by the forest is also relatively large and extends to near the airport. More than 85% of tree species are of the hardwood type. The percentage of the area occupied by these tree crowns lies in between 40-70%. But unlike the forests of Balaju and Swayambhunath, the species present in this area are not fully matured and are considered to be small timber size material. Finally, it could be concluded that the basis of development is the given natural space. The ecological balance and progress of this territory can be encouraged or destroyed, depending on whether building activity will take place in conformity with or in opposition to it. People need the presence of nature in their immediate living environment. They need to live near green areas and gardens and have clean, open water within easy reach. They also long to be able to find in this city a wide variety of plants and animals like those of the harmonious landscapes of rural areas.

5.1.7 Land use

The contemporary land use structure expresses the present use of land, the degree of cultivation and change of natural complexes. The landscape-ecological plan, therefore, cannot be made effective in the absence of the present day land use structure. It is the expression of the relationship between the natural phenomena and socio-economic condition of the study territory. In the case of the capital city Kathmandu, the most obvious dichotomy is between urbanization and agriculture. The rapid growth of the city is converting large areas of land with the highest agricultural capability in the country into urban streets and buildings. Is this good? The landscape-ecological plan must provide the answer to "what should be done about it?". The present day land use conditions, the land use change, the development and impact of built-up structures on agricultural land of the territory have been described in several publications (N.G. Ranjitkor, 1983; PADCO, 1986; The Physical Developmental Plan for the Kathmandu Valley, 1969; H. Boesch, 1972; LRMP, 1984; Kathmandu Valley Physical Development Concept, 1984). The present day land use map was prepared after field checking, in-depth aerial photo interpretation and consultation of the above mentioned literature. The land use map consists of the following land use units:

Residential: This is the most important unit of the territory. The residential units are divided after the characteristics of the housing typology (i. e. regularity of the street layout, width of the road, vehicular access to plots, size and degree of compactness of building, plot size, population density, etc.). The housing typology map (PADCO, 1986) has served for the assessment and the evaluation of the qualities of the following residential units:

1. Residential unit with moderately good settlement quality;
2. Residential unit with medium settlement quality;
3. Residential unit with low settlement quality.

The spatial distribution of each unit is expressed on the land use map. Service and commercial: This includes banks, hotels, travel agencies, major trading centres. This unit is scattered over different parts of the city. Some of these structures are accompanied by greenery elements and have played a positive role in the town environment.

Institutional: It includes all government, semi-government and corporations (hospitals, educational centers, telecommunication etc.). These elements are haphazardly distributed on the flood plain, low river terraces and upland terraces (tars).

Police/Army: This land unit is located in different parts of the city. Many greenery elements have been created within this unit and, therefore, it has played a significant role from the ecological point of view.

Industrial: It represents only one medium-sized manufacturing industrial estate called Balaju Industrial estate. This unit lies to the north of Kathmandu City.

Transportational: This includes the main bus park of the city, transportational networks and the airport.

Recreational and monumental: It includes historical buildings (Durbar Square), the Swayambhunath and Pashupathinath temple complex, some other scattered temples, stupas, gardens, sport grounds, exhibition grounds and ghats.

Arable land: Six classes of arable lands, i.e. non-terraced, well irrigated, non-terraced seasonally irrigated, non-terraced unirrigated, terraced well irrigated, terraced seasonally irrigated and terraced unirrigated have been identified in the planned territory. Among these six classes of arable land, the most important and fertile lands (in the order of priority) are land units 11, 14, 12, 15, 13 and 16. These classified land units are delineated after the irrigation classification map (Physical Development Plan for the Kathmandu Valley, 1969), the geomorphological map and the hydrological map of the planned territory. Moreover, the land units 11 and 14 are extremely fertile. These land units should not be sacrificed for the future expansion of the city. This land unit, however, should be strictly preserved and conserved.

Forest: This land unit is distributed in the Pashupatinath and Swayambhunath area and the north of Kathmandu City (near Balaju). The forests of Pashapathinath and Swyambhunath are degraded forests. However, these elements show mixed functions such as religious, recreational and protective functions.

Green elements: All indigenous and exogenous plant species scattered within the study area are regarded as greenery elements.

Fallow land: This unit is temporarily used as grazing land, partly eroded and lies close to the Tribhuvan airport. Solid waste disposal: This unit lies at the confluence between Bagmati and Bishnumati Rivers. It occupies the lower terrace site and is close to the city centre.

Vacant land: Unbuilt and partly used arable land is regarded as vacant land. Table 6 shows the urban land use in Kathmandu.

*Tab. 6: Urban land uses Kathmandu**

Land uses	**1971**				**1981**			
	Inside the Ring-Road		**Outside the Ring-Road**		**Inside the Ring -Road**		**Out-side the Ring -Road**	
	Area in Hectare	**Area in %**	**Area in Hectare**	**Area in %**	**Area in Hectare**	**Area in %**	**Area in Hectare**	**Area in %**
Residential Use	650,19	18,41	14,66	1,2	1342,76	38,02	217,41	17,92
Institutional Use	219,80	6,22	4,98	0,41	304,38	8,62	5,11	0,42
Residential / Commercial Use	4,73	0,13	0,72	0,06	8,41	0,24	0,91	0,06
Service / Commencial Use	21,84	0,62	0,73	0,06	36,32	1,03	14,20	1,15
Open Space/ Recreational Use	131,36	3,72	97,67	8,05	123,0	3,49	97,67	8,05
Industrial Use	0,29	0,01	14,78	1,21	0,71	0,02	45,00	3,71
Police / Military Use	83,54	2,37	12,17	1,00	117,82	3,34	12,17	1,00
Road	68,73	1,95	11,22	0,93	196,68	5,57	11,22	0,93
Airport	x	x	74,50	6,15	x	x	114,55	9,44
Forest	7,5	0,21	49,99	4,12	7,5	0,21	49,99	4,12
Agricultural Land	2232,65	66,22	914,56	75,39	1283,05	36,33	627,75	51,74
River	110,84	3,14	17,23	1,42	110,84	3,13	17,23	1,42
Total	**3531,47**	**100%**	**1213,21**	**100%**	**3531,47**	**100%**	**1213,21**	**100%**

** Aerial Photographs, 1971 and 1981 Computed by: PADCO, Kathmandu, 1985.*

Fig.6

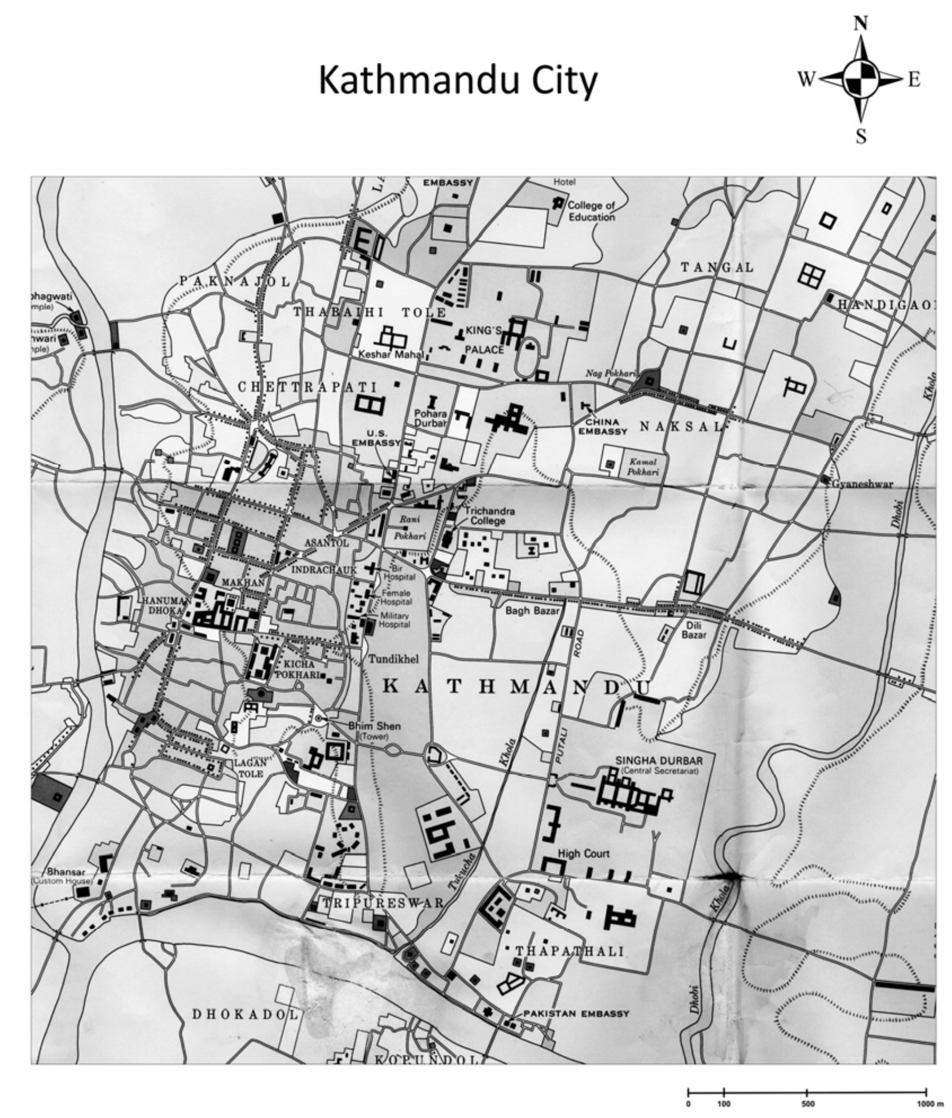


Fig. 6 Detail from Map Kathmandu-Patan, The Twin Cities Urban System (1: 12 500). Source: Nepal Geographical Society, Kathmandu, Nepal, P. P. Karan 1973.

5.1.8 Socio-economic aspects

Population growth and density

Rapid population growth is one of the major problems of the entire valley of Kathmandu. The valley has contributed a total population of 766,000 in 1981. Among the three big cities of Kathmandu Valley, i.e. Kathmandu, Patan and Bhaktapur, the capital (Kathmandu proper) is the most rapidly urbanizing area with a total population of 235,160 (1981 census). The rate of population growth is about 4.6% per annum. During the period of 1952/54, the population size was in the order of 106,579. The following table shows the percent increase during the period 1971-1981.

Tab. 7

Year	Population	% increase
1961	121,019	-
1971	150,402	-
1981	235,160	56,35

Source: Central Bureau of Statistics, HMG/Nepal

According to some estimates, Kathmandus' population density is in the order of 1200 persons/ha. However, there are great differences in population densities within the urban core, sub-urban and urban fringe areas. A recent study (PADCO,1986) showed that the core area of the city is by far the most densely populated area (i. e. 500-1200 persons/ha), whereas the lowest densities are reported to be 0-50 persons/ha. The following table illustrates ward densities in Kathmandu:

Tab. 8: Density of Urban Population of Kathmandu Nagar Panchayat

Density	Wards
0- 50 persons/ha	4, 5, 6, 8, 10, 11, 14, 15, 16
51-100 ”	1, 2, 3, 7, 13, 31, 32
101-200 ”	17, 18, 22, 29, 33
201-400 ”	12
401-600 ”	20, 21, 24, 25, 28, 30
601-800 ”	19, 23
800 and above ”	26, 27

Source: PADCO, 1986, Urban Land Policy Study

As a matter of fact, many factors have contributed to increase the rate of population growth and density in this city. The projected population (i. e. 753,000 during the period 2000) could be affected by the following factors:

- Most of the population growth is the result of natural increase (i. e. by the excess of the birth rate over the death rate within the territory);
- Increased rate of migration (regional and national);
- Illegal invasion of people, particularly from India;
- Influx of large numbers of refugees, particularly the Tibetan refugees.

Population migration

The city of Kathmandu presents an unique example in terms of population migration. A significant number of people, involving 35% of the total population of the city, have been on the move during the period of 1971-1984 (Shrestha, 1985). The lack of balance between the stage of urban growth resulting from urban bias and an increasing number of seasonal migrants are the principal factors for the increased rate of population migration in this city.

Migration has been a nationwide issue since several years past. However, this phenomenon occurring in Kathmandu shows some different dimensions and it is not similar to phenomena in other parts of the country. According to the study of the National Commission of Population (1983), the number of migrants in this city was 15,270. Out of this total number of migrants the permanent and the semi-permanent migrants were 7,728 and 5,699 respectively, whereas seasonal and temporary migrants numbered in the order of 530 and 1,310 respectively.

Numerous studies have analyzed the general trends and features of migration in Kathmandu Valley as a whole (Banskota, 1985; PADCO, 1984; Shrestha, 1985). The following points are some of the key observations:

- Migrants to the valley accounted for 8% of the total valley‘s population in 1982-82, of which 5.3% were immigrants and 2.7% were immigrants.
- The eastern and central hills accounted for the highest proportion of migrants of which Kathmandu Valley itself was an important source and most came from rural areas.
- About 37.6% of the immigrants had moved because of economic conditions in their place of origin, suggesting that the majority came to the valley for better job opportunities. The relative strength of the ”pull force” was stronger than the ”push force”.
- Immigrants were found to be engaged in community, professional and personal service concentrated in the government and semi-government jobs, while immigrants were engaged in semi-skilled and skilled jobs in the industrial, trade and commerce sectors.
- About 10,000 families are migrants in Kathmandu, of which two thirds are Nepalese. Of the immigrants about 72% are Indian in origin.
- The main sources of immigrants to Kathmandu were India (5098), Tibet (1196), Burma (71) and some non-Asian countries (303).
- Nepalese migrants by vocational categories (i.e. administrative, professional, skilled, semi-skilled and unskilled) amounted to about 69%, whereas foreign migrants in these categories added up to 31%.

Agriculture

Although the urbanization of Kathmandu proceeds very fast, agriculture is still important for the majority of the people living in this territory. Agriculture in Kathmandu is the backbone of the economic development. It is the major agricultural area of the hills and contains the only large area in which land management does not present a severe problem (Brookfield, 1983). However, the agriculture is not uniform, mainly because of the urban influence of Kathmandu City. The further away from the city, the less influenced the agriculture is. The agriculture in the Kathmandu Valley is, compared to other parts of the Middle Mountains in the Central Region, of a relatively high level. Comparison of yields of the Valley with the yields of the Middle Mountains in the Central Hill Region shows that the average yield in the Valley is much higher (Brock, 1984).

Performance in agriculture and food balance

The performance in agriculture in the field of production is far below the satisfactory level, although this sector is getting top priority since 1965. Moreover, the farming system depends upon the weather condition. Lack of good weather together with the rapid conversion of agricultural land for settlement are responsible for a decreasing yield in the food grains. Stagnation in agriculture accompanied by a rapid rise in population and accelerating urbanization have consequently reduced the per capita availability of food grains during the last decade. The food deficit in Kathmandu district during 1971/72 was around 261295 metric tons, and this deficit increased to 27,734 metric tons during the years 1980/81 (Padco, 1986). It is also projected that at the current rate of urban sprawl, about 60% of the entire valley will be urbanized by the year 2020. During 1971, Kathmandu had approximately 3147.21 ha of agricultural land, whereas during the period of 1984 it was only about 1910.0 ha.

The valley of Kathmandu, which consists of class I and class II land, is the most fertile land suitable for increased agricultural production. However, conversion of this land to urban use has greatly declined its productivity. It is also projected that an area equivalent to 35% of classes I and II will be urbanized by the year 2001 and 60% by 2010 (Padco, 1986). Details of the projected conversion of the Valley agricultural land to urban use are given in the following Table.

Tab. 9: Projected conversion of agricultural land to urban use
(Built-up area growth rate 6.52% per annum)

Year	Built-up area I land (in ha)	Remaining class and II land (in ha)	Remaining class I
1981	3,291	17,850	31,650
1991	6,181	14,960	28,760
2001	11,639	9,502	20,412
2011	21,897	0	13,051
2017	31,977	0	0

Source: Padco, 1986, Kathmandu Valley Urban Land Policy Study.

Failure of agricultural development

There are a lot of administrative bottlenecks and limitations to progress in agriculture in Kathmandu. The lack of a perfect land use regulation, poor coordination among the key sectors, contradictory policies, limited funds, poor monitoring and evaluation, lack of well-defined strategies etc. are the most important difficulties to agricultural development. Apart from the administrative problems, progress in this sector is further affected by physical, socio-economic, environmental and technical constraints. Rapid conversion of agricultural land to residential use, increased rate of migration, sparse transport and communication infrastructures, increased livestocks and traditional farming systems are the main socio-economic constraints.

Over and above, the most important constraint for agricultural development is the environmental factor. The ecological balance is worsening alarmingly due to heavy population pressure for food, fuel and fodder. The frequency of landslides, floods and erosion has increased, destroying not only marginal cultivated land on hill slopes but also prime agricultural land below the valley floor. In addition, most of the roads, bridges and other infrastructure facilities are at risk from these disasters. Varied forms of ecological imbalance have been observed at increased rates. Time has come to solve these ecological problems as fast as possible. To stop the environmental deterioration, physical works should be undertaken. Beyond this, a massive re-forestation program, improvement in farming practices, appropriate land use practice etc. are the fundamental approaches to minimize the ecological risks of this region.

Education, training, information and participation of the people in this field would contribute to make the population more aware of the impending environmental consequences and impacts. Many foreign aid agricultural projects have been established and the share of foreign aid, especially in development projects, is increasing daily. However, these projects are also severely handicapped due to the fact that:

- donors do not coordinate their projects amongst themselves and their approaches are thus too diversified;
- projects are frequently prepared neglecting local involvement;
- projects often neglect integral linkages existing between different sub-sectors and components in agriculture; and
- those methodologies so far developed without considering the existing socio-economic and environmental aspects could ultimately lead to a great failure at the regional/national level.

Marketing and processing

Agricultural markets are severally fragmented because of transportation difficulties and the absence of a sufficient market information system. Frequent restrictions imposed by government authorities on the movement of the agricultural commodities, lack of sufficient marketing centers, lack of standardized processing, grading and storage facilities all present formidable obstacles to improving agricultural marketing. Marketing of food grains is also entirely carried by the private sector. Since the last few years, the government has set support prices for wheat and paddy. These prices have, however, meant very little in the absence of an effective procurement network throughout the nation.

In the case of Kathmandu City, the population has to depend upon the food produced in nearby districts of the Bagmati zone. A large amount of food is supplied from the Patan and Bhaktapur districts of the Kathmandu Valley. Moreover, a substantial amount of cereal grains such as rice and wheat are also being brought from the so-called ”grain basket” region (Tarai) of Nepal.

Farm size

Due to the increased population and the over-all effect of urbanization, the farm size in Kathmandu is very small. More than 60% of the households own less than one hectar of land. The average size of such holdings is less than 0.5 ha. Moreover, most of these farms are fragmented into several small plots.

Cropping pattern

The main cropping pattern in Kathmandu is rice during the monsoon followed by wheat in the winter. These crops are grown on Khet land (terraces) which is surrounded by bunds and irrigated. Non-irrigated crops are also grown on level or sloping lands. Other crops are maize, potatoes, mustard and finger millet. Two basic cropping patterns: paddy-based for irrigated land and maize-based for rain-fed land are the most significant.

Paddy is the preferred crop and is grown wherever possible. About 97% of the farmers are growing rice and 87% are using improved varieties like IR<8, Taichung and Pokhareli (Brock, 1984). They are grown on almost any type of soil. If there is enough water, rice will do well on sandy as well as on heavy clay soils. It requires much skill, labour and the average farmer irrigates his rice fields nine times during the entire growth period.

The second important crop grown in this territory is the wheat crop. About 97% of the farmers are growing wheat and 97% are using improved varieties like RR<21, Lerma <52 and NL<30 (Brock, 1984). More than 60% of the Khet and level terraces are cultivated with wheat which is irrigated by 70% of the farmers.

Farmers of the research territory put very little emphasis on the maize crop. It is, however, a widely grown crop of the Kathmandu Valley. More than 79% of the farmers grow this crop using improved seed like Kakani yellow, Khumaltar yellow and Rampur yellow (Brock, 1984). This crop prefers drier areas and has a fairly low water requirement, but is also resistant to imperfect to poorly drained sites. It is also cultivated in association with other crops such as legumes, finger millet etc.

The next and most important crop of the territory is the potato. Although the potato is not a tropical crop, it is grown all over the mountain areas in the tropics. Nearly 18% of the farmers grow potatoes. More than 50% of them use improved plant materials. They are grown on every type of soil, from coarse sandy soil to heavy loam. But they prefer a well-drained sandy soil to be able to retain soil moisture. On average, potatoes are irrigated twice.

Other crops widely grown in Kathmandu Valley are mustard and finger millet. However, the farmers of the study area (Kathmandu) have given very little priority to these crops because of land scarcity, little economic value and low demand of these crops.

Agricultural inputs

Application of agricultural inputs such as chemical fertilizer is perhaps the highest in Kathmandu in comparison with other parts of Nepal. The main reasons for high fertilizer use in the agricultural field are the farmers' high purchasing power, the presence of a good transportation network and the availability of the market. It was also found that the Kathmandu Valley alone uses more than 35% of the chemical fertilizer. Moreover, many farmers realize that in order to prevent the soil from structural degradation, compost and manure are still necessary for their land; even though the price has increased tremendously, chemical fertilizers have been used almost exclusively since they were introduced.

However, some studies (BDP, 1985) claimed that the farmers are now witnessing a decrease of crop and an increase of disease. The soil is turning acidic, the natural balance of nutrients has been destroyed and chemical fertilizers do not contain the necessary ingredients for rejuvenating the soil. As a matter of fact, the farmers of the valley floor use more chemical fertilizer, improved seed varieties and, therefore, the yield of all the crops is also higher on the valley floor compared to the surrounding hills (Brock, 1984). However, the use of chemical fertilizers including manure greatly depends upon the type of the crop, irrigation facilities, varieties of seed used etc.

A recent study (Brock, 1984) provides a clear picture about the amount of fertilizer used, the mean yield and the estimated yields of the following crops of the Kathmandu Valley.

Rice

In Kathmandu Valley the average farmer uses 7580 kg/ha of compost and manure (sd 6922), and 305 kg/ha of chemical fertilizer (sd 155).
The mean yield in 1983 was 3894 kg/ha.
The estimated yields are,

for a good year	5611 kg/ha	sd 1212
an average year	4055	1972
a poor year	2479	2869

Wheat

The average farmer uses 76165kg/ha of compost and manure (sd 5472). The chemical fertilizer application rate is 288 kg/ha (sd 176).
The mean yield in 1983 was 1723 kg/ha.
The estimated yields are,

for a good year	3318 kg/ha	sd 1647
an average year	2150	434
a poor year	1017	171

Maize

The average farmer uses 11.572 kg/ha of compost and manure (sd 11.621), and 227 kg/ha of chemical fertilizer (sd 139).
The mean yield in 1983 was 1377 kg/ha.
The estimated yields are,

for a good year	2896 kg/ha	sd 1236
an average year	1799	1653
a poor year	908	0

Of the total production 70% is used in the household and 17% is used for animal fodder.

Potato

The average farmer uses 10.338 kg/ha of compost and manure (sd 8974), and 602<kg/ha of chemical fertilizer (sd 344).
The mean yield in 1983 was 11.544 kg/ha.
The estimated yields are,

for a good year	16.706 kg/ha	sd 8454
an average year	11.657	9847
a poor year	6.040	3421

Almost 50% of the production is used for the household and 33% is sold on local markets.

Mustard

The average farmer uses 9009 kg/ha of compost and manure (sd 9606) and 184<kg/ha of chemical fertilizer (sd 133).

The mean yield in 1983 was 362 kg/ha.

The estimated yields are,

for a good year	850 kg/ha	sd 387
an average year	555	486
a poor year	282	196

Finger millet

The average farmer uses 4526 kg/ha of compost and manure (sd 16.972) and 206<kg/ha of chemical fertilizer (sd 137).

The mean yield in 1983 was 1490 kg/ha.

The estimated yields are,

for a good year	3199 kg/ha	sd 1341
an average year	2049	1171
a poor year	940	485

Of the total production almost 70% is used in the household, about 10% is sold. Millet is used for flour, local beer and spirits (tumba, chang and roksi).

Industry

Industrial growth is a leading motor for the development of a city like Kathmandu. It has played a vital role in providing employment and facilities for the past few decades. Most of the agro-based industries are located in urban centers to take advantage of the proximity to service, transportation links and non-farm labour forces.

Kathmandu has the greatest variety of industries with an emphasis on consumer goods such as food, beverages, textiles and clothing. Moreover, the industries have skilled labour forces, a good transportation network and probably the highest urban infrastructure of all urban centers in Nepal.

The present state of industry in Kathmandu

Most of the industries of Kathmandu are in the embryonic stage and these industries have not yet contributed to fulfill the desired economic development of this region. The development of a large number of industries is also severely handicapped due to the lack of a sufficient water supply, raw materials and hydro-electric power supply. Establishment of large scale industries in Kathmandu is also not feasible. The main constraints for industrial development in Kathmandu could be summarized as follows:

- Scarcity of exploitable natural resources and hydropower (though supply of hydro electricity is higher than in other regions of Nepal, it is still not sufficient for the potential development of industry);
- Inadequately trained manpower;
- Small domestic market and low per capita income;
- Its land-locked position, which makes it difficult and costly to import raw materials.

At present, Kathmandu is facing many difficulties in the supply of raw materials, both imported and local products. The main problems items which have to be imported include: synthetic and non-synthetic textiles, pig iron, iron and steel in various forms, oil seeds, sugar, milk powder, chemicals and packing materials. Local products inadequately supplied are cement, wood, handicrafts, furniture and other materials.

Industrial establishment in Kathmandu

Out of seven industrial districts of Nepal, only one industrial estate – Balaju Industrial Estate – is located in Kathmandu. This industry is under the control of the Industrial Service Center and in full operation. The number of industries within this estate is 47, housed in 35.4 ha of land. Balaju industry, though not a large scale industry, has played a central role for manufacturing several items. In the current process of establishment (opening) of industries, different industries are being established in arbitrary places.

However, the following types of industries are reported in Kathmandu (Padco, 1984):

- Agro-processing (including food, footwear, grain mills);
- Wood and wood processing;
- Textiles and clothing;
- Bricks and tiles; and
- Other manufacturing (printing, drugs, soap, metal fabrication, jewellery).

Kathmandu Valley also serves as a center for the wood and wood products industry of the entire hill area of the country. The following table provides the regional distribution of industrial establishment.

Tab. 10: Regional distribution of industrial establishments (Location Quotients)*

	Industry Type				
	Agro**	**Wood**	**Textile/ Clothing**	**Brick/Tile**	**Other**
Kathmandu Valley	0.27	1.34	0.81	0.85	1.41
Other Hill Districts	0.66	0.84	2.55	0.97	0.62
Terai	1.75	0.81	0.28	1.14	0.88
No. of Establishments	180	210	111	65	199

** Location Quotient = Percentage of industry "x" in region*
Percentage of all industry in region

*** Does not include grain mills, which constitute 75% of all establishments; almost three-quarters of the mills are in the Terai. Source: Padco, 1984. Nepal Urban Development Assessment.*

Employment

The absolute level of employment in the industry is very small as compared to agriculture. However, Kathmandu, Patan and Bhaktapur, the principal cities of Kathmandu Valley, account for 29% of the national urban employment, but for 37% of industrial urban employment. It is projected that Kathmandu plants would require 837 additional employees. The greatest number of employees is found in metal, engineering and electricity (2865), followed by bricks, cement etc. (1680) and textiles and footwear (1370).

Table 11 provides an idea about the number of employees (male and female in the various industrial groups in Kathmandu.

Tab. 11: Employment in industry groups Kathmandu

Industry Group	Number of Establishments	Employment		
		Males	Females	Total
Food, Beverages etc.	13	822	146	968
Textiles, Footwear etc.	14	1,039	311	1,370
Wood and Wood Products	8	439	33	472
Chemicals, Plastics, etc.	4	129	23	152
Metal, Engineering, Electricity, etc.	18	2,798	67	2,865
Bricks, Cement, etc.	6	1,659	21	1,680
Handicrafts	4	117	50	167
Miscellaneous	2	171	13	184
Total	**69**	**7,174**	**684**	**7,858**

Source: Padco, 1984. Nepal Urban Development Assessment.

Transportation

Transportation is of rapidly growing importance in Kathmandu and despite very difficult physiographic conditions, there is an ongoing program of road building. It is one of the major generators of employment and plays a significant role in the distribution of essential goods and services, increases assets through the impacts on property value and on the productivity of equipment utilized by entrepreneurs and it increases the supply of land suitable for settlement.

Other important impacts of the transportation development in this region are:

- Increased public revenue;
- Influence on the productivity of both private and public investments;
- Guided land use pattern and land value; etc.

Expenditure on roads

The expenditure on roads construction is increasing year after year. Great attention regarding construction, management and regulation has been provided by the Ministry of Works and Transportation, the Town Development Committee and Kathmandu Nagar Panehayat.

The budget allocated for this sector is increasing. However, less money was allocated during the year 1984/85 (Bashnet, 1985). Moreover, the following table provides a general picture about the investment and the maintenance cost of urban roads since 1978.

Tab. 12: Expenses on urban roads in thousands of rupees

Fiscal Year	Investment in Roads	in Urban Roads	Percentage of total expenditure	National Maintenance Budget Allocated	Budget expenditure
1978/79	427,994	4,617	1.05	17,000	16,862
1979/80	430,639	1,576	0.05	18,000	17,984
1980/81	472,194	5,750	1.22	19,000	19,008
1981/82	543,369	6,314	1.66	20,000	19,416
1982/83	473,004	19,000	4.02	25,000	19,700

Source: Office of the Controller General, HMG Budget Estimate Speeches, IDS (1983, 11-13)

From the data available about urban roads in three towns of Kathmandu Valley, it is clear that during the fiscal years 1982/83 and 1983/84 5% percent and 6% of roads constructed in the whole country were located in the Bagmati zone, leading to the conclusion that the most intensive road building activity has been taking place in and around the Kathmandu Valley (Bashnet, 1985).

Road network connecting Kathmandu

Four major highways now radiate out from the Kathmandu Valley to other parts of the country; one goes to the south, connecting the Tarai, and one to the east, connecting the eastern hill areas, and two to the west, linking the western hill areas.

Kathmandu is connected by two all-weather roads to the main east-west highway (Mahendra Raj Marg) at Hautada and to Tarai and to the Indian border town of Birjung. The first and older road leads first southwest from Kathmandu for about 26 km to Naubise, then south-south some 107 km to Hautada over the southerly range of Mahabharat.

Roads in urban Kathmandu

Though Kathmandu has more and better quality roads than other parts of Nepal, they are too narrow. However, the roads network is still below the required standard for the city. Traffic congestion is remarkable considering the low actual volume of vehicular traffic and it is due to the penetration of vehicles into the narrowest streets and their constant effort to force their way through the mass of pedestrians.

A survey on the urban roads in Kathmandu indicates the following types of roads in connection with their length in kilometers.

Tab. 13: Urban roads in Kathmandu

Year	Black-topped	Graveled	Fair weather	Total (km)
1982	84	34	51	169
1984	101	82	76	259

Source: Nepal Sadak Sthiti (1982 and 1984)

Traffic and means of transportation

The traffic problem is among the greatest problems of the urban population of Kathmandu today. In Kathmandu Valley alone there are more than 30,000 automobiles (Gorkhapatra, 11 Feb. 1983). There are more than 10,000 motorcycles and an equal number of private, public, governmental and non-governmental motorcycles. The figures provided by the Department of Housing and Physical Planning is even more alarming.

The main vehicles used in Kathmandu are cars/jeeps, trucks, buses, motorcycles, cycles, tempo etc. The growth rate of vehicles is about 10% per year (DHPP, 1973). According to the survey of DHPP, 1973, and the Bagmati Zone Police Office, 1986, the total number of vehicles during the year 1965, with an annual growth rate of 14.1% was only 4384. However, there was a dramatic increase in the number of vehicles after the year 1972. The total number of vehicles recorded during this period was around 11059. During the year 1982, the figure jumped up to 23940 with an annual growth rate of 11.7%. The highest growth rate was found to be 12% during the year 1984. Moreover, the following table provides the composition of vehicles registered in the Bagmati zone up to 1972 and in 1983, 1984 and 1985.

Tab. 14

Type	Total Number Registered				Percentage of total in			
	up to 1972	in 1983	in 1984	in 1985	1972	1983	1984	1985
Cars & Jeeps	6012	674	764	868	54.4	30.2	24.3	34.4
Trucks	1554	87	998	259	14	3.9	31.8	10.3
Buses	398	59	113	179	3.2	2.7	3.6	7.1
Motor cycles	3043	1334	1127	1072	27.5	59.8	35.9	42.5
Tractors	46	27	127	81	0.4	1.2	4	3.2
Tempos	6	50	10	62	0.5	2.2	0.4	2.5
Total	11059	2231	3139	2521	100	100	100	100

Source: Department of Housing & Physical Planning (1973, 12) and Bagmati Zone Police Office (December, 1985)

Cars and jeeps formed 54.4% of the vehicles registered in the Bagmati Zone up to 1972, but after that there has been a sudden rise in the numbers of motorcycles. Their number increased from 1972 to 1982 at the rate of 23% per year, this percentage becoming higher towards 1982 and reaching 10028 from 3043. During 1983, 1984 and 1985, they have increased most in Kathmandu. Almost 60% of the vehicles registered in 1983 were motorcycles.

The number of users of public transportation is increasing at an average rate of 8% per annum. More than 20,000 passengers are arriving at Kathmandu by more than 200 public and private buses. It has been estimated that about 40% of the road users in Kathmandu town area are constituted of pedestrians and 25% of traffic in this town area of cyclists and rickshaws (KVPT, 1984). According to Shrestha, 1985, about 84.0% commute to the City of Kathmandu from the selected outlying bus terminals and most of them are service holders, students, farmers, and some foreigners. The use of cars and taxis is limited as well as expensive. They are used for transportation by some higher-income families, while urban buses are used by most Kathmandu residents and visitors.

Traffic problems in Kathmandu

Besides many administrative and institutional problems such as lack of coordination, funds, manpower, planning and policies etc., the following are the main problems associated with the transportation in Kathmandu:

- Excessive maintenance cost for roads;
- Inconvenience and economic losses due to increased urban sprawl and the construction of too narrow streets;
- High cost for operation and maintenance of outdated automobiles;
- Loss of agricultural land due to inefficient survey, layout and proper road construction;
- Increased health hazard as a result of noise, air, water and land pollution;
- Increased rate of accidents, etc.

From the above mentioned problems, it could be concluded that the traffic problems of Kathmandu are severe and great effort is needed to alleviate these problems.

Tourim

Many foreigners are of the opinion that Nepal is ”perhaps the last paradise” on earth. A magnificent, mountainous landscape and a rich cultural heritage have attracted hundreds of thousands of tourists annually. It has been reported in a study of the Pacific Area Travel Association (PATA) that the beautiful natural scenery, the beautiful man-made environment and friendly people are the main tourist attractions in Nepal. The flow of tourists is yet another good indicator of the economic role of Kathmandu. It has been seen as one of the most promising industries for Nepal that is least handicapped by the limited domestic market. It is estimated that 87% of the tourists arrive directly in Kathmandu. Gross foreign exchange from tourism has grown steadily and it is found that about 60% of the gross earnings are retained in Nepal.

Of the total annual arrivals (about 165,000 in the last three years), treckers and mountaineers constitute 13%, business and official visitors 7%. Official statistics classify the other 80% as ”pleasure visitors”. The average length of stay is about 10 days. However, the rate of tourist arrivals slowed considerably after 1978, reflecting the impact of world economic recession and the rising cost of a visit to Nepal (World Bank, 1983). Between 1962 and 1981 the number of tourists visiting Nepal increased by 26 times from 6179 to 161669. The average per capita expenditure also increased substantially from RS 126 in 1962/63 to RS 5657 in 1981. In 1982/82 tourism contributed about 22% of the total foreign exchange earnings in Nepal. It has given a major spur to the growth of the hotel industry both in Kathmandu and outside. In 1964, there were only 280 hotel beds, but in 1981 this increased to over 3000, giving rise to a significant excess capacity considering the seasonal changes. The over-occupancy rate stood at the low level of only 36% for Kathmandu in 1981 (World Bank, 1981). It is felt that the number of rooms plus planned facilities will be adequate to accommodate the potential growth in the tourist trade. Studies on tourist expenditure have shown that if 50% is spent on food and lodging, handicrafts and curios share about 24% and internal travel 19.78%, leaving 5.27% to recreation and miscellaneous (Banskota, 1985).

The most important source of tourists had been India in 1983, sending 32.9% of the total number of tourists traveling by air. Other Asian countries, except Thailand, have not been an important source of tourists. Other main sources were the U.S.A. (17.3%), Germany (9.5%), U.K. (9.8%), France (8.8%), Japan (7.8%) and Italy (7.7%).

Impact of tourism

It was already mentioned that this dynamic sector has been one of the chief indicators of the economic development of the country since 1970. Moreover, tourism has played a more important role in the economy of this region than in any other part of the country as it provides direct or indirect employment to professional groups like tourist guides, those employed in the carpet industry, curio shops and handicrafts etc. The tourism industry directly created jobs for people like hotel staff, civil aviation and travel agency staff. Nevertheless, this sector continues to present the following problems (World Bank, 1983):

- Slackening growth in tourism in recent years;
- High import content of the tourism support machinery;
- Socio-cultural and environmental deterioration of the region as a result of unplanned management, lack of adequate regulations, poor facilities and services, etc.

The quality of the cultural experience of visiting the monuments of Kathmandu is affected by the accessibility and particularly the traffic. Many sites are already congested and the increased flow of visitors will add to the congestion. The reservation of certain areas for pedestrian access and the provision of the parking spaces for tourist buses requires priority attention. The movement of vehicles inside the major areas, such as Durbar Square, the Pashupati Temple area and other important sites of Kathmandu, should be controlled and restricted as soon as possible.

5.1.9 Nature conservation and protection – problem identification

Protection, conservation and management of nature and its resources are the fundamental approaches to the balanced development of the city. Kathmandu City is a dynamic and open-ended system. It must be, therefore, regarded as a component of the wider rural ecosystem.

The development objective of the city is that it must continue to provide employment and increasing income, health, housing and educational needs. Conservation of nature and retention of its quality, therefore, becomes synonymous with social welfare. The role of nature conservation is to ensure that the greatest benefit is given to the present generation, at the same time ensuring that such benefits can continue for future generations. It does this by understanding the behavior of nature and natural resources, in particular those characteristics which govern their management. They are renewable if conserved and often irreversibly destructed if not (Nature Conservation Strategy for Nepal, 1983).

The lack of sufficient natural space within the urban area of Kathmandu seems to be one of the greatest barriers to sound ecological development. One of the basic reasons of the degradation of nature is the lack of established principles of protection of citizens' rights to the benefits resulting from rational space management and to the contact with a harmonious landscape. The second reason lies in poor spatial planning and this results from not taking into consideration the economic analysis based on the value of space. The third reason and probably the most important reason lies in the lack of sufficient space needed for nature conservation.

The problems of nature conservation could be identified and elaborated from the report "National Conservation Strategy for Nepal, 1983). The report states that "Nepal has made a good start in achieving conservation, but deforestation, soil erosion, sedimentation, flooding, reduction of natural resources and the genetic diversity of problems urgently require co-ordinated action". Furthermore the report stresses that "...obstacles to achieving conservation are inadequate environmental and natural resources planning, failure to integrate conservation with development, lack of broad conservation awareness...".

The above mentioned statements are not in exception for the heart of the nation – Kathmandu City. The natural quality of the cityscape of this region is even more disheartening and rapidly deteriorating due to increased human activities. Conserved areas either in the form of small woodlands or other open spaces including agricultural fields are limited in space, number, degree, level and distribution of vegetational species. As a result of heavy encroachment, traditionally conserved areas are loosing their identity owing to the internal forces of competing demands of urban transportation, housing and industrial production.

The most important prerequisite for a healthy open space policy is the retention of the natural green areas. However, the structure of nature and landscape has largely been destroyed, open and green areas have been ruthlessly decimated. Those which remain are inadequate and have deteriorated into waste areas, have shrunk to nothing more than narrow strips of green. Open ground which used to drain water has been built over, covered with concrete and asphalt. The sealing of the ground, the pollution of the air, the excessive warmth and dryness prevent the healthy growth of what vegetation remains. The whole landscape has changed and the people have been separated from nature. The city has become a stone desert, a cold inhospitable environment. The role and the value of the natural environment present in the immediate vicinity has been sadly neglected. Arrogance and carelessness of the people have led to an increasing environmental crisis. They have forgotten to safeguard nature and the countryside worth safeguarding.

Nature conservation in the planned territory

Evaluation and justification for nature conservation areas in the planned territory are still a difficult task. As a matter of fact, the term ”nature conservation” is a vague term and covers a broad aspect of the environment within the study area. In general, nature conservation areas should be treated as an entity free from any human encroachment and/or interference. Moreover, most of the undeveloped land including agricultural land and other remaining open fields could be discussed separately under nature conservation and protection. In a broad sense, protection and conservation of arable land, meadows, pastures and grasslands by means of optimal landscape-ecological planning could contribute a lot to balancing the nature of Kathmandu City. Its unlimited functions and increasing carrying capacity in terms of production, therefore, depends upon the successful land use regulations and optimal landscape ecological planning.

However, for simplification of this study, only the following woodland areas are considered to be important conservation and preservation areas of Kathmandu City:

- Swayambhunath woodland areas;
- Balaju woodland areas;
- Pashupati woodland area.

A brief account on cover type, species abundance, crown density and maturity class of the woodlands has been given in chapter 5.1.6.

Apart from the above mentioned woodland areas, there are still a few small-sized woodland areas scattered around the city. These elements are equally significant for the ecological balance of the whole region. They are characterized by the following features:

- They represent one of the oldest and most important endemic floras of Kathmandu Valley;
- They are still able to provide shelter to a large number of wild animals, particularly wild birds and some vertebrates; and
- They are still capable of maintaining the ecological balance of the city to some extent.

5.2 Landscape-ecological synthesis

The aim of synthesis is to create types (LET) and regions as ecologically homogenous and heterogenous units (for details see chapter 4.2).

5.2.1 Typification of landscape-ecological complexes

The landscape-ecological typification is based on the parametric typification of abiotic, biotic and anthropic factors. The number of parameters to be considered for landscape-ecological planning depends on the type of problem, the objective of the study and the disposition of the background materials which are necessary for the cartographic overlay procedures.

The most important analytical ecological parameters selected for this territory are:

- Geomorphological units,
- Angle of slope,
- Soil types, and
- Land use.

The following four non-interpreted parameters have been used for synthesis. In the framework of abiotic sphere:

1.Parameter of the five place code (1XXXX) – geomorphological unit (i. e. the numerical code of the following units will be the first code of types of landscape-ecological unit):

1 = river channel and sand bars
2 = alluvial plains without man-made terraces
3 = lower river terraces without man-made terraces
4 = lower river terraces with man-made terraces
5 = terrace edges
6 = non-dissected ancient river terraces without man-made terraces
7 = non-dissected ancient river terraces with man-made terraces
8 = dissected ancient river terraces without man-made terraces
9 = dissected ancient river terraces with man-made terraces
10 = moderately to steeply sloping mountain terrain

2. Parameter of the five place code (X1XXX) – angle of slope (i. e. the numerical code of the following units will be the second place code of types of landscape-ecological units):

1 = 0 – 1° level (assumed no relief energy)
2 = 1.1 – 3° nearly level (assumed negligible relief energy)
3 = 3.1 – 7° gently sloping (small relief energy)
4 = 7.1 – 12° moderately sloping (medium relief energy)
5 = 12.1 – 17° nearly steep sloping (nearly great relief energy)
6 = 17.1 – 25° steeply sloping (great relief energy)
7 = Above 25° very steep sloping (very great relief energy)

3. Parameter of the five place code (XX1XX) – potential soil units (i. e. the code of soil units will be the third place of the code of the types of landscape-ecological units):

1 = psamments and ustifluvents
2 = fluvaquents
3 = haplaquents
4 = haplaquepts
5 = dystrochrepts and ustorthents
6 = haplaquepts and ustochrepts
7 = ustochrepts
8 = rhodustalfs
9 = dystrochrepts and haplumbrepts

In the framework of biotic and socio-economic sphere:

4. Parameter of the five place code (XXX11) – land use and vegetation units (i. e. the numerical code will be the fourth part of the code of types):

1 = residential with moderately good settlement quality
2 = residential with medium good settlement quality
3 = residential and commercial with low settlement quality
4 = service and commercial
5 = institutional
6 = police and army
7 = industrial
8 = transportation
9 = reserved land for airport extension
10 = recreational and monumental
11 = non-terraced well irrigated arable land
12 = seasonal irrigated arable land
13 = unirrigated arable land
14 = terraced well irrigated arable land
15 = seasonal irrigated arable land
16 = unirrigated arable land
17 = forest
18 = green element
19 = rivers, streams and ponds
20 = fallow land
21 = solid waste disposal
22 = vacant land

By the cartographic overlay of the coded geomorphological map with the coded map of angle of slope, a partly synthesized map is obtained. This map is again made ready for the next overlay with coded soil units. As a result, a more complicated abiotic synthetic map with three places of codes is prepared. Finally, this synthetic map is confrontated with coded land use and vegetation. As a matter of fact, this map consists of landscape-ecological units or types (LET) with five place codes. This landscape-ecological type acts as the operating unit and means that each working operation of evaluation and proposition is carried out for each type (or sub-type) and the result is valid for all surfaces of the given type in the studied area. In the scheme of the synthesis, the types are coded by numbers which are ascribed to individual values of indices in the analytical part. The scheme of synthesis for the planned territory is expressed in Table 15.

Tab. 15 Scheme of LET (cutting)

PROPERTIES OF TYPES						PROPERTIES OF SUBTYPES												
MORPHOLOGICAL UNITS	CODE	ANGLE OF SLOPE	CODE	POTENTIAL SOIL UNITS	CODE	RESIDENTIAL 1, 2, 3 CODE	OTHER BUILT UP AREAS 4, 5, 6, 7 CODE	TRANSPORTATION 8, 9 CODE	RECREAT-MONUMENT 10 CODE	ARABLE LAND 11, 14 CODE	ARABLE LAND 12, 15 CODE	ARABLE LAND 13, 16 CODE	FOREST 17 CODE	GREEN ELEMENTS 18 CODE	RIVER, STREAMS 19 CODE	FALLOW LAND 20 CODE	SOLID WASTE DISPOS. 21 CODE	VACANT LAND 22 CODE
RIVER CHANNEL A. SAND BAR	1	0°-1°	1	PSAMMENTS A. USTIFLUVENTS	1										11119			
ALLUVIAL PLAINS WITHOUT MAN-MADE TERRACES	2	0°-1°	1	FLUVAQUENTS	2	2121 2122 2123	2124 2125 2123		21210	21211 21214	21212	21213			21219			
	2		1	HAPLAQUENTS	3	2131 2132 2133	2135			21311	21315							21322
	2		1	HAPLAQUEPTS	4	2141 2142 2143	2144 2145 2146		21410	21411 21414	21412	21413		21418				
	2	1,1°-3°	2	FLUVAQUENTS	2					22211	22212							
	2		2	HAPLAQUENTS	3	2231 2232 2233	2235			22311								
	2		2	HAPLAQUEPTS	4	2241 2242 2243	2245 2246		22410		22412							
	2	3,1°-7°	3	FLUVAQUENTS	2					23211								
	2		3	HAPLAQUENTS	3	2331 2332				23311	23312 23315	23313				23320		
	2		3	HAPLAQUEPTS	4						23412	23413						
LOWER RIVER TERRACES WITHOUT MAN-MADE TERRACES	3	0°-1°	1	HAPLAQUEPTS	4	3141 3142 3143	3144 3145 3146		31410	31411	31412	31413						
	3	1,1°-3°	2	HAPLAQUEPTS	4	3241 3242 3243	3245 3246		32410									
	3	3,1°-7°	3	HAPLAQUENTS	3						33315							
	3		3	HAPLAQUEPTS	4		3314 3345 3346											
LOWER RIVER TERRACES WITH MAN-MADE TERRACES	4			FLUVAQUENTS	2	4122												
	4	0°-1°	1	HAPLAQUENTS	3	4131 4132	4137			41314	41315	41313 41316	41317					
	4			HAPLAQUEPTS	4	4141 4142 4143	4144 4145 4146		41410	41411 41414	41412 41415	41416					41421	

5.2.2 Functional regionalization of landscape-ecological complexes

The functional regionalization of the landscape-ecological unit is the result of typification. It shows the spatial differentiation of territorial units with specific characteristics. The region also consists of an unrepeatable composition or structure of the landscape-ecological types or complexes. Moreover, the regions also serve for a total characterization of the territory as well as a basis for the separation of the functional units.

The following two main criteria were selected for the delimitation of the regions:

- geomorphological units;
- present day land use within the geomorphological units.

The characteristic features of the functional regions are summarized and evaluated in Table 16. This table consists of two main physiographic regions called the ancient river terraces (tars) and the alluvial plains (dols). It also covers the following three main aspects:

- Prevailing functions (e. g. residential, institutional, monumental, agricultural etc.) in the particular region;
- Occurrence of the main landscape-ecological complexes; and
- Potential ecological risk as a result of urbanization processes.

The table reflects that the regions 1, 2, 3, 4, 5, 6, 7, 8 and 9 are characterized by residential, service/commercial, monumental and institutional functions. All these regions are the most suitable site for the urban development processes. The regions are also greatly influenced by recent forms of urban expansion and lie close to the center of the city. However, the regions 10, 11 and 13 are far from the city core. These regions are primarily used for agricultural production and shoe very few urban features. Region 9 shows high potential ecological risk because of the construction of the airport.

The second physiographic unit which consists of the regions 13, 14, 15, 16, 17 18, 19, 20, 21, 22 and 23 is the most potential site for agricultural production. The regions 18 and 19 are far from the city center. These regions are therefore still under the attack of the urbanization process. The regions 23 and 24 are partly urbanized and show the highest potential ecological risk as a consequence of the present day uncontrolled development of the city. These peculiar features are noticed in region 14. This region, which lies close to the Bishnumati River, is easily vulnerable to pollution, and other health hazards owing to unregulated drainage, low settlement quality and dumping of municipal wastes. The region 17, originally the most suitable site for vegetable and crop production, is now totally used up by institutions, residences and other urban functions.

Tab. 16: Functional regionalization of landscape-ecological complexes

Prevailing function in the particular regions	**Main physiographic units**					
	Tars and mountainous terrain			**Dols**		
	Number of funct. reg.	**Main landscape-ecol. complexes**	**Potential ecol. risk**	**Number of func. reg.**	**Main landscape-ecol. complexes**	**Potent. ecol. risks**
R-S-C-M	1	6163, 61610	low			
R				13	4231, 4331	high
R-It	2	6161, 6165	low			
R-It	3	9171, 8215	low			
R-A*	4	6171, 61813	low	14	2122, 21211	high
R-A	5	7172, 71715	low	15	4241, 41416	medium
R-A				16	4131, 41314	high
It-M-R-S	6	6165, 61610	low			
It-S-C-R				17	3145, 2141	medium
P/A-R-M-F	7	5276, 6272	low			
Id-R-M-F	8	8167, 8162	low			
T-M-F	9	8168, 8162	high			
A	10	6171, 61716	low	18	21211, 21311	high
A	11	71715, 72715	high	19	21311, 42415	high
A	12	71715, 71716	high			
A-R*				20	21211, 2211	high
A-R*				21	21211, 2122	high
A-R*				22	21211, 2121	high
A-R*				23	42415, 4242	medium

R = residential; S = service; C = commercial; M = monumental; It = institutional; A= agricultural; A = partly agricultural; P/A = police/army; F = forestry; T = transportation*

B. Ecological optimization of the landscape utilization

5.3 Evaluation of ecological data on the territory

The main purpose of this part is the evaluation of the types of landscape-ecological complexes and the functional regions of the landscape-ecological complexes (for details see methodological part).

5.3.1 Selection of indices of ecological properties of the landscape

The analytical landscape-ecological properties such as geomorphological conditions, angle of slopes, potential soil units and land use expressed in the LET act as indices. These indices are ordered in Table 15 of the landscape-ecological complexes and their spatial distribution is cartographic expressed.

5.3.2 Selection of social or man's activities (i. e. selection of functional elements)

The selection of social activities in the landscape is based on the spatial requirements of the practice for certain activities securing the development of the society. Their combination and planary requirements for the selected activities are given to each territory on the basis of the plans of its development.

General priorities

First of all, the general priority areas have been identified for the landscape-ecological planning for Kathmandu as a whole. But depending upon the problems of different functional regions, i.e. urban core, sub-urban areas and urban fringe areas, a more specific list of priorities has been designed for each functional region. Specific priorities for the above mentioned areas of Kathmandu will be briefly mentioned after the general priorities for the planned territory.

The general priorities include:

- Agriculture
- Preservation
- Housing
- Open space/recreation and forestry
- Institutions
- Transportation
- Industry
- Others

Agriculture

The highest priority has been given to the protection and the preservation of the most fertile agricultural land of the planned territory. Top priority for agricultural purposes is based on the facts that:

- The agricultural land of Kathmandu is one of the most fertile and productive areas in Nepal;
- The agricultural land strictly falls under class 1 land (in terms of production, capacity, irrigation availability);
- Land management does not present severe problems;
- A wide variety of crops such as rice, wheat, maize including many vegetables, especially potatoes, could be produced in sufficient quantities;
- Only a very few natural constraints have been visualized, i.e. a minor danger of soil erosion, landslides and floods;
- Agricultural inputs (fertilizers) could be made available due to the presence of markets and infrastructural facilities;
- Unlike other mountain regions, investment in land, i. e. labour and capital, is very small;
- Many environmental problems of urbanization could be minimized if the agricultural field is not used for other functional purposes, especially housing, industry and transportation.

Preservation

One of the most important aspects of landscape ecological planning is the preservation of the existing man-made and natural environment of the planned territory. The man-made environment which embraces all forms of construction is not necessarily important for our purpose but emphasis should be given to those structures which are very important from a socio-cultural, archaeological, historical, environmental as well as touristic point of view. The historic and religious places are the animate and inanimate artistic creations of a unique culture. However, these elements are rapidly deteriorating, being encroached upon by ”modernization” throughout the valley (Pruscha, 1969).

Landscape-ecological planning gives top priority to the preservation of these structures. In connection with this issue, LANDEP also supports the views as expressed in the Physical Development Plan for the Kathmandu Valley (1969). Moreover, future development should be controlled in the following historic areas:

- Durbor Square;
- Pashupatinath temple complex;
- Swayambhunath temple complex.

In addition to the preservation of the above mentioned areas, priority has been given to the preservation of the forests, greenbelts, open space, parks and water bodies of the study area.

Housing

After agricultural land, most of the land of this region is occupied by residential units (approx. 156 ha). Unfortunately, this element is tremendously growing at the expense of the fertile soil and some open space. Lack of appropriate land use planning, regulation and enforcement have created a lot of socio-economic and environmental problems. Haphazard infill in both low residential areas of the sub-urban zone and the agricultural field of the urban fringe are the common features of the present day urbanization process in Kathmandu. Moreover, low income families are purchasing cheap land around flood areas and highly productive grounds. These areas are also severely handicapped by the lack of infrastructural facilities and a drainage system. Living conditions in these low income settlements often constitute a hazard to the human environment. The misuse of land and the lack of proper services in these areas have led to land and water pollution, which is becoming a severe threat to the health and well-being of the population. This tendency is expected to increase in the future if immediate action (i. e. land use planning, zoning ordinance, regulation etc.) is not taken by the authorities responsible.

The process of urbanization is inevitable. It is, therefore, necessary to evaluate a potential site for optimal utilization of land for residential purposes. Moreover, priority for residential use should be based on the following points:

- Identification and proper allocation of a suitable site for residential use;
- Development and enforcement of more efficient land use plans, land regulations etc.;
- Provisions for the development of a special zone for future residential development;
- Provisions for infrastructural facilities such as transportation, water supply, electricity, drainage, solid waste disposal, etc.

Open space

Any space (land and/or water) resource that is, has been or will be used for recreation and at least one other compatible purpose is a real asset to the urban/sub-urban and fringe dwellers. Unfortunately, most of the open space is already being changed for the worse in function and form. As a result of the present trends of development, the lack of sufficient open space, especially in the urban core area, is becoming a real problem. Furthermore, the government is also using public open space for construction and works, depriving the city dwellers of recreational benefits and of a healthy environment (Ranjitkar, 1983). Growing slums along the river banks of the Bagmati and the Bishnumati rivers and the establishment of small-size business oriented shops, inspired by unaware panchas, not only swallowed up the remaining open space but also polluted the environment even more.

As a matter of fact, the protection and creation of open spaces will also minimize many environmental problems in this overcrowded city. At the same time, possibilities for recreation should be made available for the benefit of citizens and foreign visitors alike. In an optimistic view it is believed that opportunities are available at little or no cost if one takes the effort to find and take advantage of them.

In short, priority for open space has been given with a view to:

- Make room for recreation facilities;
- Minimize the potential environmental hazards (noise, air pollution) resulting from overcrowding and vehicular movement.

Institutions

Prior to 1973, most of the governmental buildings including the ministries, departments and many branch offices were located within the historic palace of the Singha Durbar. Unfortunately, this famous palace which is among the oldest in Kathmandu was destroyed by a fire. The government was, therefore, forced to establish new buildings on prime agricultural land in the sub-urban and urban fringe area in a haphazard way. Many new roads were constructed and many other infra facilities made available. These activities not only occupied the fertile soil but also served as a force attracting thousands of people for whom new residential units had to be constructed. The result was a further socio-economic and environmental impact on these fertile agriculture lands.

Even though the palace went up in flames many years ago, the government offices are still scattered all over Kathmandu (KCTPT, 1984) and more are expected to be constructed in the near future as a result of new developmental activities. Priority has to be given to institutional development with a view to preserve the agricultural land on one hand and to control the haphazard expansion on the other hand by allocating appropriate land in a planned way.

The following criteria have to be considered when allocating land for institutional purposes:

- Relatively good access to the major transportation networks;
- Relatively low density of population near to the proposed area so that the population around these locations would suffer less from the potential danger of air and noise pollution resulting from vehicular movement;
- Infrastructural facilities should be adequate.

Industry

It is a well-known fact that industrial development is an inseparable part of urbanization. Establishment of different types of industries ranging from small-scale to large-scale industry not only improves the economic condition of the country but also helps to minimize the problem of unemployment.

In the context of Kathmandu, however, very little emphasis has to be given to locating industries especially around the urban and fringe areas. Moreover, the government should discourage industrialists to establish large and heavy industries with a view of minimizing urban bias, pollution and traffic congestion. However, the problems of unemployment and environment could be reduced by planned and controlled development of the tourism industry which seems to be the most suitable alternative to the future development of Kathmandu. Thus, little priority is attributed to the industrial development, except for the tourist industry and this is based on the following assumptions:

- There is very little space for the establishment of industry. The space available at present is suitable only for residential, commercial, institutional and agricultural development;
- There will be a potential danger of environmental problems such as air, water, land and noise pollution if industrial development is encouraged;
- The problem of traffic congestion will be further increased if the land for industry is allocated in an inappropriate place (i. e. within the city);
- The lack of potential resources and facilities (i. e. water, electricity etc.) is on of the major constraints for the development of new industries.

Specific priorities

The nature of the problem, the structure, functions and characteristics of the urban core, sub-urban areas and urban fringe areas differ from one another. It is, therefore, necessary to provide a brief description and more specific priorities for the following areas.

Urban core

The core is one of the oldest settlement areas of Kathmandu. It is mostly used for residential and commercial purposes. However, most of the valuable buildings, monuments and temples are also concentrated in this area. The main problems of the city core in Kathmandu are basically environmental, i. e. air and water pollution, noise, traffic congestion, solid waste and drainage. The lack of sufficient facilities and services in this densely populated core (i. e. above 500 persons/ha) have made the situation even worse. Out of the 33 wards of Kathmandu Nagar Panchayat, 14 wards, i. e. wards 12, 17, 18, 19, 20, 21, 22, 23, 24, 25 26, 27, 28 and 30, are located within the urban core.

The order of priority for this core includes:

- Preservation (historical buildings, monuments, temples and open spaces);
- Creation and development of a new landscape (i.e. greenery elements);
- Residential and commercial uses;
- Transportation (parking space for vehicles and development of loading/unloading facilities).

Sub-urban areas

This area lies close to the urban core, i.e. in the northern and eastern parts of the old city center (see Fig. 4). Environmental problems are not as severe as those of the urban core. However, the traffic congestion along the too narrow streets and the problems of solid waste and drainage cannot be neglected. The population density is relatively lower than in the core (51-200 persons/ha). The sub-urban areas consist of 10 wards (i. e. 1, 2, 3, 4, 5, 11, 29, 31, 32 and 33). The list of priorities for this functional zone includes:

- Housing;
- Open space creation and preservation;
- Institutions; and
- Transportation.

Urban fringe areas

This area represents one of the sites with the best potential for agricultural production. Almost all kinds of vegetables, especially potatoes, tomatoes etc. could be produced in sufficient quantities. This area, at present, is under severe attack from urban expansion and has attracted thousands of low-income families. The population density is reported to be 0-50 persons/ha. There are four fringe wards at the west bank of Bishnumati River (i. e. 13, 14, 15 and 16), whereas the eastern fringe area consists of five wards (6, 7, 8, 9 and 10).

The order of priorities for the urban fringe areas is:

- Agriculture;
- Preservation of the most important religious places, greenbelts and forest;
- Transportation; and
- Industry (if necessary).

5.3.3 Assessment of suitability or capability of the landscape-ecological complexes for human activities

This methodological step is the central part of the evaluation. It is, therefore, necessary to know (or to find out) the degree of suitability of each indices of landscape ecological complex (LET) that are occurring in the particular region. Its assessment is a complicated process in which one decides according to the criteria determined beforehand, based on the valid norms for individual kinds of activities. Besides that, the local or commonly valid limiting factors for individual functions are determined and taken into account.

The first methodological step for suitability assessment is the selection of the negative values (limit values) from each landscape-ecological complex of the planned territory. The assessment and th evaluation of LET have been carried out with the help of table 17.

Tab. 17: Evaluation table with limiting values

Potential Human Activities Elements	**Agricultural**	**Resi-dential**	**Service/ Commercial**	**Institutional**	**Historical Building**	**Police/Army**	**Industry**	**Transportation**	**Open Space/ Recreation**	**Forestry**	**Green**
Landscape-ecological indices	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
1. Geo-morphology	1,5, 10	1,2,3,4, 5,8,9,10	1,2,3,4, 5,8,9,10	1,2,3,4, 5,8,9,10	1,2,3,4, 5,8,9,10	1,2,3,4, 5,8,9,10	1,2,3,4, 5,8,9,10	1,5,8, 9,10	1,2,3, 4,5	2,3,4, 6,7	-
2. Angle of slope	4,5, 6,7	5,6,7	4,5,6,7	3,4,5, 6,7	3,4,5, 6,7	3,4,5, 6,7	3,4,5, 6,7	4,5, 6,7	-	1,2	-
3. Soil type	1,5, 8,9	1,2,3, 5,9	1,2,3, 5,9	1,2,3, 5,9	1,2,3, 5,9	1,2,3, 5,9	1,2,3, 5,9	1,2, 3,5	1,2, 3,5	2,3,4, 6,7	-

Explanations to the table 17

Geomorphological Units:	**Angle of slope:**	**Potential soil units:**
1 – River channel and sand bars	**1** - 0 – 1°	**1** – Psamments and Ustifluvents
2 – Alluvial plains without man-made t erraces	**2** - 1.1 – 3°	**2** – Fluvaquents
3 – Lower river terraces without man-made terraces	**3** - 3.1 – 7°	**3** – Haplaquents
4 – Lower river terraces with man-made terraces	**4** - 7.1 – 12°	**4** – Haplaquepts
5 – Terrace edges	**5** - 12.1 – 17°	**5** – Dystrochrepts and Ustorthents
6 – Non-dissected ancient river terraces without man-made terraces	**6** - 17.1 – 25°	**6** – Haplaquents and Ustochrepts
7 – Non-dissected ancient river terraces with man-made terraces	**7** - more than 25°	**7** – Ustochrepts
8 – Dissected ancient river terraces without man-made terraces		**8** – Rhodustalfs
9 – Dissected ancient river terraces with man-made terraces		**9** – Dystrochrepts and Hamplumbrepts
10 – Moderately to steeply sloping mountainous terrain		

This table shows that the limit values of the geomorphology, i. e. 1, 5 and 10 (river channel, terrace edge and moderately to steeply sloping mountain terrain respectively) do not favor agricultural production. Moreover, the limit values 4, 5, 6 and 7 (i. e. the slopes of 7-12°, 12-17°, 17-25° and above 25°, respectively) cannot support the desired yield. At the same time, the limit values 1, 5, 8 and 9 (psamments and ustifluvents, dystrochrepts and ustorthens, rhodustalfs, dystochrepts and haplumbrepts) are the negative values which restrict agricultural production. Apart from these limiting values, the capability or suitability of these complexes (LET) are also determined by other natural characters and socio-economic conditions of the planned territory.

The evaluated landscape-ecological complexes are shown in Table 18.

Tab. 18 (cutting)

CODE OF LANDSCAPE-ECOLOGICAL COMPLEX (LET)	SUITABILITY FOR THE PROJECTED SOCIO-ECONOMIC ACTIVITIES OR FUNCTIONAL ELEMENTS												RESULT OF ELIMINATION A.ORDER OF THE „LET" SUITABILITY FOR:						
	AGRICULTURAL	RESIDENTIAL	SERVICE/COMMERCE	INSTITUTIONAL	HIST.-OR. BUILDING	POLICE/ARMY	INDUSTRY	TRANSPORT	OPEN SPACE	FORESTRY	GREEN ELEMENT	GRASS LAND	BASIC FUNCTIONAL ELEMENTS					COMPLEMENT. FUNCT. ELEMENTS	
	A	B	C	D	E	F	G	H	I	J	K	L	I	II	III	IV	V	I	II
111													K						
212													A						
213													A						
214													A						
221													A						
222													A						
223													A						
224													A						
227													A						
232													A						
233													A						
234													A						
314													A						
324													A						
333													A						
334													A						
412													A						
413													A						
414													A						
422													A						
423													A						
424													A						
432													A						
433													A						

CODE OF LANDSCAPE-ECOLOGICAL COMPLEX (LET)	SUBTYPES OF „LET" (PRESENT-DAY LAND USE)												
	RESIDENTIAL	OTHER BUILT-UP AREAS	TRANSPORTATION	RECREAT. MONUMENT.	ARABLE LAND			FOREST	GREEN ELEMENTS	RIVER, STREAMS	FALLOW LAND	SOLID WASTE DISPOS.	VACANT LAND
	1,2,3	4,5,6,7	8,9	10	11,14	12,15	13,16	17	18	19	20	21	22
111										P=K			
212	N=B	N=C,D,F		M=I	P=A	P=A	P=A			P=H			
213	N=B	N=C,D			P=A	P=A							M→A
214	N=B	N=C,D,F		M=I	P=A	P=A	P=A		P=K				M→A
221	N=B												
222					P=A	P=A							
223	N=B	N=D			P=A								
224	N=B	N=D		M=I		P=A							
227					P=A				P=K				
232					P=A								
233	N=B				P=A	P=A	P=A				N→A		
234						P=A	P=A						
314	N=B	N=C,D,F		M=I	P=A	P=A	P=A						
324	N=B	N=D,F		M=I									
333						P=A							
334		N=C,D,F											
412	N=B												
413	N=B	N=G			P=A	P=A	P=A	P=J					
414	N=B	N=C,D,F		M=I	P=A	P=A	P=A					N→B	
422					P=A								
423	N=B				P=A	P=A			P=K				
424	N=B	N=C,D	N=H	M=I	P=A	P=A	P=A				N→A		
432	N=B						P=A						
433	N=B	N=C			P=A	P=A	P=A						

This table reflects the suitability of the particular landscape-ecological elements. These units are also arranged by priority. For example, the landscape-ecological complexes 212 and 214 are the most suitable sites for agricultural production, whereas the unit 413 is not as suitable as the first unit (i. e. 212).

The second methodological step for suitability assessment is the elimination of the negative activities from each landscape-ecological complex. This step is made possible with the help of the above mentioned table 18. The result of the elimination is shown in the elimination part of table 18.

The third methodological step is the arrangement of each functional element in the order of priority for each landscape-ecological complex (see table 19).

Tab. 19: Scheme of suitability of landscape-ecological complexes for functional elements on the planned territory

	Order of suitability of LET						
Functional Element	1	2	3	4	5	6	7
Agricultural	212	214	222	223	224	314	413
Residential	616	617	618	627	716	717	718
Service / Commercial	616	617	618	627	716	717	718
Institutional	616	617	618	627	716	717	718
Historical building	616	617	618	627	716	717	718
Police/Army	616	617	618	627	716	717	718
Industry	616	617	618	627	716	717	718
Transportation	616	617	618	716	717	718	414
Open space / recreation	1019	1029	1039	1049	818	818	838
Forestry	1079	1069	1059	575	565	555	545
Green Elements	555	545	535	938	937	838	836

5.3.4 Assessment of convenience of contemporary utilization of the landscape ecological complexes

The assessment of suitability of the contemporary land use is the most determinant factor for the allocation of the optimal activities. Moreover, the present day land use is responsible for the suitability of each landscape-ecological unit. Establishment of suitability of the contemporary use of the LET is, in other words, the determination of suitability of localization of the element of land use on a given LET. The occurrence of elements in the land use is evaluated in a simple three grade scale, such as:

1. Positive phenomenon (in the table indicated by P),
2. Possible phenomenon (M),
3. Negative phenomenon (N).

The evaluation is expressed in the same table 18, but this part lies at the right side of the table. Moreover, the evaluation results in some of the principles of proposition of a new landscape structure. The principles are:

1. If the contemporary use of LET is evaluated as a positive phenomenon, the present use (present fundamental functional element) should be maintained on the given LET and improved by contemporary functional elements; or
2. If, as a possible phenomenon, we have the larger possibility of proposition which will be ruled by the principles presented further on; or
3. If, as a negative phenomenon, the present use should be changed.

5.4 Landscape-ecological proposition

5.4.1 Primary proposition

A proposal is the process of the optimal localization of socio-economic activities in the landscape. It is aimed at the harmonization of the ecological properties (potential) of the landscape with its utilization for the purpose of development of man and society. Primary proposals are also governed by certain principles and limitation factors in the planned territory. The principles of suggesting a new landscape structure starts from the determination of the suitability of contemporary use of LET, and from the fundamental requirements/demands of the society. The principles also recognize a certain level of compromise between the ecological, socio-cultural and economic conditions.

The selected principles for this territory are:

1. Protection of the fertile soil;
2. Preservation, conservation, protection and improvement of already built-up areas.
3. Conservation, maintenance and preservation of the existing forests and greenery elements;
4. The principle of suggestion, which results from the tradition, from the up-to-date development and so on (e. g. preservation of religious forests, ghats (cemeteries), temples, monuments etc.);

Besides the above mentioned principles, the following limiting factors which correct and improve the contemporary land use are taken into consideration:

Natural limiting factors:

- Extremely flood-sensitive areas;
- Potential site for shallow well field;
- Apparently good areas for off-channel storage scheme;
- River bed protected with barrier;
- River bed without barrier;
- Permeability of the geological substratum .

Socio-economic limiting factors:

- Special protective zone;
- Population density (person/ha) in each ward;
- Land value;
- Rope way;
- Transmission line;
- Ring road;
- Protected zone of the airport.

The decision making processes for primary propositions are based on the above mentioned limiting factors and principles. The result of the primary proposal is expressed and in the proposal part of Table 19.

5.4.2 Secondary proposition

The secondary proposition represents an arranged and re-evaluated result of the primary proposition according to the spatial requirements of society for individual functions, with regard to relations to adjacent areas, to the size of individual areas, etc. The map of primary propositions is further modified.

As a matter of fact, the secondary proposition is the final product of the landscape-ecological planning method. The map of primary propositions is somewhat complicated and gives a more detailed view of the territory. Primary proposal is again generalized to certain regions, so that the town planners have a better choice for future developmental processes. The process of regionalization is based upon certain principles, i. e. a grouping of certain functional elements (or types). It determines the general characters of landscape functionality and according to this fact functional categories were formed, which can also contain several allied functional elements. The functional categories appear as the regions of landscape. The division of the given territory for the individual functional categories can be named the functional regionalization of the territory. This regional map is optimal from the landscape-ecological point of view and it does not necessarily concern the present day activities (land use). The potential regionalization map has been prepared after the confrontation of the suitability map.

While the result of the primary proposition and one part of the result of the secondary proposition have the character of functional typification of territory, the second part of the secondary proposition has the character of regionalization of the landscape functions.

From the suitability point of view, the studied area has been divided into 21 great regions. The regions 1, 2, 3, 4, 5, 6, 7 8 and 9 occupy a great area. These flat tars are the most suitable area for future building program for housing, institutions, service, commerce and for the creation of greenery elements. From the ecological point of view, this area is the most suitable because the angle of slope is level, the territory is not dissected (i. e. compact), it is relatively drier than other parts of the territory, there is no danger of floods and other natural constraints, and there is only little danger of ground water pollution. However, the level of air pollution could be increased if necessary measures are not taken.

Among these regions, the regions 2, 9, 3, 5 and the northern part of region 1 are the most suitable sites for housing. From the ecological point of view, the regions 3, 4 and 5 are the most suitable sites for housing purposes. These regions also consist of fairly large pockets of undeveloped land. To save the prime agricultural land of the 'dol' regions, most of the undeveloped land (though potential site for agricultural production) can be sacrificed for the future urban expansion, i.e. future infill should be encouraged within these regions. Region 6 (Tahachal and Dallu) is the most suitable site for housing and agricultural production.

The regions 10, 11 and 12 are potential sites of arable land. These areas are extremely sensitive to monsoon floods, carry a high risk of ground water pollution (if urban expansion is encouraged) and, if the fields are level and mostly unterraced, show a high possibility of irrigation supply which produces higher yields than in other regions.

The urban planners of Kathmandu should restrict, control, regulate and conserve the remaining undeveloped land of this region. However, region 7 (Kalimati and Ravibhawan) is suitable for mixed functions. This region is primarily suitable for housing, agriculture and forest. The regions 8 and 9 are potential sites for housing, forest and green elements. The regions 14, 15, 16, 17, 18, 19 and 20 are potential sites for forest and other greenery elements. Among these regions, the potential forests of the regions 15, 18 and 20 have been greatly changed by increased human activity.

Moreover, the construction of the airport in region 20 has created a great impact on the overall environment of this region. It is, therefore, necessary to support, conserve and protect the remaining vegetation of these regions. Apart from these proposed activities, the regions should be supported for recreational and religious purposes.

After the process of regionalization, a final map of secondary propositions of optimal land use was prepared. This map was prepared after the evaluation and confrontation of the LET suitability with the present land use and limiting map.

5.5 Protection and creation of environment

5.5.1 Analysis of environmental problems

The protection and creation of the landscape (environment) represents a further stage of proposition, in which the proposal of an ecologically optimal landscape structure is compared with valid documents of landscape-ecological planning. The main aim of this methodological part is to create a new landscape scenery with the help of green elements, forests etc.

Impact of human activities on the environment

Kathmandu City as we know it today was an ecologically balanced landscape in the remote past. The man-made environment in the past has been a very complex and delicate urban ecosystem for the propagation of the well-being and the vitality of the people in harmonious partnership with natural processes.

Historically, a small population and limited land use had little effect on the overall ecological balance of this region. The natural environment of this traditionally based rural-urban setting was itself capable of maintaining, regulating, supervising and controlling the human activities within the limited space. The negative impact of human activities was never expected beyond the threshold limit and, therefore, the metabolic function of the city was perfect in accordance with the governing principles of nature.

But since the past decade, the growth of Kathmandu has become explosive. As a result of increased human activities, a far-reaching change in the environment has been set in motion. The ecological balance is severely disturbed due to the wasteful exploitation of natural resources such as land, flora and fauna, water and air, manifesting itself in the water, air and land/soil pollution. Increased activities in and around the urban areas have created profound environmental impacts (visual), namely, building with electric architecture not conforming with traditional buildings endowed with vernacular archetypes and indigenous materials, change of facades of traditional structures by cosmetic application, bizarre boarding and sign boards in and around monument areas, ugly service poles, overhead wires and allied fixtures, visually offensive roads and parkings, unhealthy noise, smell, garbage, human/animal excreta, drainage etc.

These factors undermine and jeopardize the sensitivity of any micro-environment of significance. Hence it could be concluded that the visual as well as the socio-economic perception of the environment of the traditional society is being eroded, slowly but surely.

Despite many plans and programs of HMG/N such as a Physical Development Plan for Kathmandu Valley, a Tourism Master Plan, a Land Use Plan for Kathmandu etc., as well as the implementation of many sectoral plans, the cultural and natural environment is deteriorating because of multiple impacts generated by recent forms of developmental processes. Some illegal tourist-related activities have further created an unhealthy atmosphere. In this regard it is worthwhile to mention the loss and decay of many priceless monuments, temples and other valuable materials.

The list is long: loss of Shiva and Bishnu temple from Balaju, loss of the famous Shiva-linga from Deopatan, loss of the greatest and marvelous Narayan temple of Patan, loss of Sarswati temple of Pharping, etc. These man-made tourist attractions in terms of cultural heritage encompass past glories of arts and architecture regarded as the heart and life of the city. The location of these artifacts and monuments are determined by socio-economic and religious roles. Unfortunately, these illegal activities hampered not only the proud image and fame of the society but also had a negative impact on the international level, too.

One of the negative results of rapid urbanization is the growing degradation of the urban/sub-urban and rural landscape as well as the destruction of these areas and their specific climate. The haphazard and unplanned growth or urban encroachment not only swallowed the existing agricultural land of the fringes, but in future will also threaten the environmental quality of the town (Ranjitkar, 1983). Pruscha (1969), while dealing with the preservation of the physical environment of Kathmandu Valley, pointed out that the growth of a large urban agglomeration and institutional establishment has not only resulted in destruction of the countryside but it has often achieved the creation of places no long desirable to be lived in (DHPDP, 1969).

In spite of the full awareness of the government of the present trends of environmental deterioration, the desired goals of many plans are still not fulfilled. As far as the emphasis on the environmental planning is concerned, the activities are limited to paper only. A little attention was given to the "Project Urban Planning", Nepal, 1973. Environmental planning including identification of environmental problems and the formulation of measures for the protection of the natural and man-made environment of human settlements etc. were mentioned as the immediate objective of the "Project Urban Planning". This project also emphasized that the job of the environmental planner was to review the existing physical and tourism development plans for the Kathmandu Valley and other major urban areas, to determine the environmental impact of the plans, recommend action programs and projects to ensure environmentally sound implementation of the plans, as well as to recommend legislative and regulatory measures for the area. Unfortunately, the project did not go beyond a few timely sectoral studies and the job of an environmental planner as mentioned in the "Project Urban Planning" is to be fulfilled by sensitive planners of the future.

The natural environment of Kathmandu is a part of an ecological system. It is, therefore, necessary to have a general overview of the environmental conditions of this region. Many ecologists are of the opinion that the environmental conditions are deteriorating at an accelerated rate. According to Rieger (1985), "the rapid environmental degradation of the more densely populated mid hills of Nepal [where Kathmandu lies] is now an established fact". The rapid degradation of the environment is not only associated with only one aspect such as the demographic situation of this territory, but several aspects including cultural, religious, economical, international aspects etc., which are all intimately connected with each other and the lack of principles to these aspects has created the current crisis . Besides many socio-cultural and economic problems, the overall environmental problems could be summarized as follows (Rieger, 1985).

- General increase in all forms of erosion;
- Increase in silt and gravel load of streams and rivers;
- Increased danger of destruction of infrastructure works such as roads, bridges, houses, hydro-plants, terraces etc.;
- Greater incidence and extent of floods in endangered areas;
- Adverse change in micro-climate;
- Lowering of ground water table;
- Negative down-stream effect due to increased sediment load; and
- Accelerated shift of river beds in the plains.

Mans' impact on the land or land consumption

Among the environmental elements (e. g. land, water, flora, fauna and air), land is the important resource of this territory. The space is limited but the demand for many functional elements such as settlement, agriculture, industry, forest, transportation etc. is expected to increase tremendously. In principle, highly productive agricultural land and forest of this region have the highest priority for conservation. Every developmental plan should be very sensitive in avoiding the development of productive land. But the land use problem, as a result of increasing urban expansion, is a particularly serious environmental issue in Kathmandu. The haphazard development or urban structures in the most fertile land has threatened the urban ecology and the environmental quality of this region (DHPD, 1969). The preservation and improvement of the existing agricultural land is a top priority for the balances development of the valley as a whole. However, land use data are scarce and conflicting. Based on the statistics (Padco, 1986), the cultivated and uncultivated land of Kathmandu City is reported to be 4744.68 ha. The cultivated area was 1910.98 ha during 1981, whereas the forest land occupied only 57.49 ha or 1.21% of the total land.

Haphazard expansion of settlement, especially on the arable land, is a serious matter of concern in recent years. Unplanned settlement, mushrooming of industries and institutes in haphazard fashion, increasing exploitation of soil by a large number of small-scale brick factories, increasing land pollution from outdated automobiles, improper disposal of solid wastes etc. have created a serious impact on the land resources. As the planning history suggests, most of the settlements were exclusively planned and built on non-irrigated high lands, raised platforms and even on hilltops. All settlements were built in a compact form using as little horizontal space as possible, but showing a strong tendency towards vertical expansion. Well-irrigated and fertile farm lands were fully utilized for exclusive agricultural purposes and the forests were sacred communal property and the boundaries protected against encroachment.

Now, the situation has changed completely. Most of the undeveloped land has been transformed from a natural to a man-made configuration. Predominantly man-made environments are subjected to various forms of developmental changes, all of which are not desirable. The environmental impact of land consummation can be estimated only after detailed land use plans and statistics are available (Kastarlak, 1974).

The land use data suggest that the greatest impact on the land was made due to the rapid conversion of agricultural land into built-up area. In 1971, agricultural land use in Kathmandu town Panehayat accounted for 14%, institutional and open space about 5% and others were less than 2%. But within a decade (1971-1981) Kathmandu expanded both physically and functionally. The agricultural land declined from 66% to 40% (3147.21 ha to 1910.8 ha). The land use data further suggest that almost all other functional elements such as residential, institutional, industrial etc. have increased on the expense of agricultural land. Residential areas increased from 14 to 33%, whereas industrial land use increased only from 0.31% to 0.96% (15.07 ha to 45.71 ha). Virtually all urban land uses increased in percentage terms with the exception of open space/recreational space which declined (Padco, 1986). Ranjitkar (1985) stressed that the establishment of industries, construction of roads, institutional structures and commercial set-ups have greatly facilitated urban encroachment on prime cultivated land. Increase in tourist flow and growing relations with friendly countries caused a shortage of establishment of hotels, travel agencies and embassies in the congested core areas of the city and thus replaced the agricultural land of the urban fringe to a great extent. Furthermore, the recent forms of residential development occurred not only in ”tar” areas but in low lands adjacent to the flooding areas. These tendencies have brought far-reaching impacts and changes, especially in agricultural land utilization, land use and land values in the peripheral areas of the city.

Water pollution

One of the greatest problems faced by the urban dwellers as well as the rural inhabitants of Kathmandu is the problem of water pollution. Especially pollution of the Bagmati river and its tributaries arisen from dumping of unwanted residues, deposition of acids/alkali, plant cleaning operations etc. from the industrial sector and mainly domestic organic pollution from the urban sector. The main pollutants of these water bodies are reported to be fecal coliform, toxic compounds, nutrients, suspended solids, BOD, oil and other chemical substances such as sodium, potassium, ammonium, lead, nitrate, calcium, chloride etc. (Sharma, 1979, Khatri, 1986).

Water pollution in Kathmandu is generally caused due to several reasons such as municipal wastes and agricultural wastes. Municipal waste comes from settlements, commercial establishments and industries. The increasing rate of water pollution in Kathmandu could be dealt with in the following points.

Water pollution by sewerage disposal

The sewerage disposal system is not good enough and the direct discharge into the water courses without proper treatment is having a negative impact on the surface water of the Bagmati, Bishnumati, Dhobikhola and Tukucha rivers. The most outstanding fact found was that all the water samples had different concentrations of coliform bacteria. According to one investigation, the density of coliform bacteria was 460/100 ml of water (Sharma, 1979), whereas the desirable ambient standard is about 200/100 ml. According to another study (Singh, 1978) the water bodies were not only contaminated by non-pathogenic bacteria, but also showed contamination with pathogens, mainly Escherichia coli, Vibrio coli, Salmonella sps; E. coli was reported to be 130 million per 100 ml in 1978. Furthermore, the river Bishnumati, which is practically nothing but an open sewer, is assumed to contain more pathogens and industrial waste than the Bagmati River. Lack of sufficient sewage treatment facilities and shortcomings of the existing system seem to be the major causes leading to increased water-borne and fecal disease. In the present absence of a sewage system, water pollution is widespread and constitutes a growing hazard to all who use rivers and streams or who depend on ground water in the lower parts of the valley (Brookfield, 1983). Sharma (1978) claimed that there is a high possibility of contamination of piped drinking water due to abuse as well as technical layout close to the sewer line.

Water pollution by solid waste

The increasing amount of municipal waste is another potential source of water pollution. It is estimated that the average load of domestic solid waste is 60 tons/day or 400 gms/head/day. It is claimed that the Solid Waste Management Board (a German-financed project) has covered about 50-52% of Kathmandu Nagar Panchayat for road and street cleaning and is managing waste collection points covering 70% of Kathmandu (see Map 23). Lack of regular service from these collection points has created increasing health hazards. Establishment of a pilot compost plant at Teku and the selection of a dumping site at Gokarna have both threatened the quality of life. The location of the compost plant, which serves as a primary dumping site, at the confluence of Bagmati and Bishnumati has further increased the level of water pollution. It is said that this compost plant is vulnerable by its proximity and it closeness to the main water courses. The Gokarna dumping site is likely to pollute the surface water, ground water and static water (Sharma, 1986). Perhaps the greatest impact could be leaching to the Bagmati River nearby. The local people are greatly affected by its noxious smell. It has been heard that the locals are requesting the concerned authority not to dump huge amounts of solid waste any more in the future. The decreasing life span of Gokarna as well as the lack of an alternative site for dumping the solid waste in Kathmandu would be the next problem for the solid waste planners of this region.

Water pollution by industry

Analysis of much background material reveals that large-scale industries polluting water bodies are not established in this territory. However, construction of small-scale industries and factories have contributed to pollute the surface water of this area. Many industrial pollutants are directly poured into these water bodies without any treatment. Besides these small-scale industries, there are a large number of small-scale activities such as workshops, welding shops and pottery works, repairshops etc. around the city. In a collective form these activities too create environmental pollutants of a different nature.

The following is a list of industries which are assumed to pollute water as well as causing other forms of pollution in Kathmandu.

• Leather and shoe factory	1
• Cement factory	1
• Dye factory	1
• Battery factory	1
• Bricks and tiles factory	2
• Local bricks factory and kilns	25
• Balaju industrial estate	1

The recent establishment of the battery factory at the Balaju site is supposed to be the most dangerous water polluting factory in the years to come. However, the Balaju industrial estate is said to be a manufacturing industry but up to now there is no visual indication of its contributing to water the pollution.

The leather and shoe factory, lying close to the study area, is supposed to affect Kathmandu City. Out of the total raw hides entering the tannery, 40% are converted into solid and liquid waste or to by-products (Sharma, 1985). The liquid effluent is directly discharged into the Dhobi Khola with toxic compounds such as sulphides, phospates, chromium together with suspended particles and dissolved solids and other organic materials.

Water pollution by surface drainage

Surface drainage is directly connected with domestic waste and hand-flushed latrines. The septic tank effluent containing a high bacterial content is generally discharged into surface drains which become polluted and odorous. Furthermore, increasing water logging inside the city is a common occurrence. No place of Kathmandu is free from these problem. The problem of water pollution is greatly intensified by poor maintenance of existing drainage, lack of sufficient drainage facilities, deposition of construction materials around drainage sites and the disposal of garbage in inlets and drains.

Water pollution by fecal disposal and chemical fertilizers

The problem of water pollution in Kathmandu City is further increased by defecation in open fields, on the river banks and on waste grounds. This practice is primarily due to the traditional habit of the people as well as, secondarily, due to the lack of sufficient private and public toilets. In 1980, about 60% of the households had latrine facilities inside the houses and 23% outside the houses. The rest used public toilets or defecated in the field (Basynet, 1985). The public toilets available are also extrememly unhygienic and poorly maintained. Most of the temporary visitors are therefore compelled to defecate in the open fields.

Another important source of water pollution is the use of chemical fertilizers. The outflow of these chemicals either directly or through leaching from agricultural fields finds it way into water courses. Inefficient agricultural practice and the steep topographical features of the basin have also played a significant role in polluting streams, springs, lakes and ponds of this region. Increased run-off of chemicals (i. e. herbicides, insecticides, pesticides and others) along with water thus affects the taste, turbidity and color of the water and supports the growth of weeds which cut down the dissolved oxygen content of the water. This in turn affects aquatic life adversely.

Moreover, the amount of chemical fertilizers used in this region is far greater than in other parts of Nepal. The following table provides some idea about the use of the chemical fertilizers for the major crops of this region.

Crop	Use of chemical fertilizer kg/ha
Rice	305
Wheat	288
Potato	602
Maize	227

Water pollution by automobiles

The large number of automobiles is also responsible for polluting the water due to washing and cleaning operations along the riverside. During these cleaning operations, toxic oil drops are directly mixed with water. This practice is common mostly near the bridges of the Bagmati, the Bishnumati and the Dhobi Khola.

Apart from the above mentioned sources of water pollution, it is claimed that the river Bagmati is badly polluted by the Royal Drug Research Institute and the maternity hospital (Thapathali) as the effluent water wastes are directly poured into the Bagmati (Maypuria, 1985). Moreover, increasing slums around the Bagmati and Bishnumati river courses are equally responsible for the increasing degree of water pollution.

Based upon the analysis of the above materials, field observations and a critical overview of some investigations (Sharma, 1979, Khatri, 1986), a general map of the water pollution of Kathmandu has been prepared (see Map 10).

Mans' impact on the flora

Among the environmental elements, the existing vegetation occupies a central position for the ecological balance of the entire region of Kathmandu City. The general vegetational condition has been described in chapter 3.1.6. This chapter tries to focus on the impacts of human activities resulting from recent forms of developmental changes.

Kathmandu City, though itself in the process of rapid urbanization, has shown the following impacts on the overall vegetation including the remaining forest:

- Loss of general vegetational cover (herbs, shrubs and small trees) in open fields as a result of uncontrolled urban expansion. The loss and change of the vegetational cover could be evaluated by comparing the aerial photos of present day land use forms to that of the historical one;
- Rapid felling and destruction of isolated patches of the remaining tree species for household needs.

Besides the overall impacts on the local environment due to the lack of humus, reduced infiltration, loss of soil nutrients, loss of ground water storage, intensified drought, siltation of streams and reservoirs, etc. the effects of population pressure on the surrounding parts of Kathmandu Valley are most serious matters of concern. The ecological balance is worsening alarmingly due to the over-exploitation of vegetation for fuel and food. Furthermore, this is compounded by the fodder demands for the large number of livestock population.

The ecological problems experienced in the hills and mountains have serious repercussions for the valley and plains below. Deforested and disturbed slopes cannot regulate and slow the rapid run-off of water and they begin to loose soil easily. Rivers rise quickly, flooding and silting of low lands destroys crops and property and causes great human suffering. When watersheds are stripped of their forests and vegetative cover, drought can occur as the soil looses its ability to absorb and hold water which could be released later in springs and streams. As life conditions in the high land deteriorate and with few alternatives to make a living available locally, many people migrate to the low lands and urban areas seeking subsistence.

The cycle of destruction of the vegetational cover is elaborated in diagram 1. The diagram summarizes the harmful environmental impacts that attend destruction of the forest resources. It could, therefore, be concluded that wide-spread damage to Kathmandus' ecology and environment has already been caused by deforestation, urban sprawl and inappropriate land use practices. This process continues largely unabated and unless checked, will lead to the ultimate destruction of the entire ecosystem and calamities of enormous proportions. Protection and conservation of the flora and optimization of land use in accordance with ecological conditions and demands are thus requirements of paramount importance. The progressive future and the healthy environment of this region depend upon the successful protection and conservation of the forest of the surrounding valley. Any developmental activities without considering this aspect could result in great failure. It is therefore suggested that the planners of Kathmandu survey and evaluate the existing vegetation as well as carry out a large-scale afforestation program in the appropriate vicinity of human habitation.

Air pollution

The Valley of Kathmandu is especially vulnerable to air pollution. Renowned for its crystal-clear blue skies, the valley might be hard-pressed in preserving this aspect of its environmental quality in the future. Increasing numbers of automobiles, trucks and other machines and jet aeroplanes might soon begin to contribute to the pollution of the air in significant quantities (Kastarlak, 1974). The number of vehicles and other means of transportation as a source of air and noise pollution has been described in chapter 3.1.8.4.5.

Massive use of fuel wood by the increasing number of households, establishment of a large number of industries and unlimited growth of the number of automobiles have contributed to the increasing rate of air pollution during the past decades. Moreover, the 'bowl'-like topography of Kathmandu valley is also easily vulnerable to air pollution. The basin is surrounded by mountains, poorly ventilated by the flow of wind and contains many dusty flat land. Due to these topographical features, the flow of the air is prevented and an inversion layer may move up and down. This layer serves as a canopy and prevents both vertical and lateral depression of contaminants. From October to February there are no mountain winds present as a result of ground inversion (Kiesewetter, 1980) and ultimately the polluted air comes to the ground in calm weather.

Air pollution through firewood consumption

In the absence of sufficiently modern forms of energy – electricity, gas etc. – the people of this region have to depend upon firewood for their household needs. About 83% of the domestic energy comes from the firewood. This form of energy in Kathmandu could be therefore regarded as a chief source of air pollution. While using firewood for domestic purposes, many houses in this region do not have a chimney or even an adequate opening in their kitchen through which smoke can escape. The trapped smoke, besides being uncomfortable, affects the health of the occupants.

Air pollution by industries

Another potential source of environmental threat is the smoke generated by industrial plants. Pollution generated by the industries has really become an environmental issue. As Nakajima, et. al., 1980, explains: "The worst consequence of city growth is the atmospheric input of particles from wood and coal burning, powerfully augmented by the cement and brick factory. In a situation with minimal air drainage below 1500 m, the temperature inversion in the air below 250 m of the valley atmosphere produces frequent winter fogs which in the western parts of the valley become smog that often persists long after the fog itself has cleared". This effect can be observed especially in the late spring and early summer months.

Construction of the Himal cement plant and fertilizer factory in Chauber has not only badly affected the landscape but also human beings (Majpuria, 1985). As a result, a section of the village from this vicinity has migrated to Tarai. It is supposed that the smoke visible in the city will completely obscure the panorama of the Himalaya if due care is not taken. The landscape of Chauber was once a lure to artists who would spend time there painting; now nobody likes to visit the place.

The cement plant is located in the southwest corner of the valley and it was found that nearly one third to one half of the valley could be within the "smoke fan". This plant, with a capacity of 48000 tons of cement per annum, is releasing particles from the vertical kilns in the range of 26000 to 30000<m^3 of dust-laden gas per hour. This in turn is affecting the surrounding areas within 300 m with a dust deposit (Sharma, 1986). In the same way the rotary kiln emits 21500 to 25000<m^3 of dust-laden gas per hour. In 24 hours about 5-6.4 tons of dust are emitted; of this amount 1.25 tons have less than 10<m size (Sharma, 1986).

Besides the cement plant, huge amounts of dust particles are emitted by the leather and shoe factory. As a result, a small population in the vicinity at the radius of 500 m is severely afflicted and the influence on the settlement in this area is negative.

The large number of brick kilns within Kathmandu and two other brick producing factories in Patan and Bhaktapur districts are also supposed to increase the air pollution in the Valley.

Air pollution by automobiles

The large number of automobiles in modern Kathmandu has been a serious problem. Gaseous pollutants from automobile exhausts have not only threatened the quality of life, but have changed the entire environment to such an extent as making it inhabitable for people. The movement of a large number of old vehicles in too narrow and badly maintained streets, the lack of sufficient green vegetation, jamming and congestion of these structures, the lack of sufficient parking space, inefficient traffic regulations etc. are becoming the real problems of the urban dwellers. The automobile produce exhaust fumes consisting of CO_2, CO, NO_2, SO_2 etc. in huge quantity. According to one study, the automobiles in

Kathmandu alone emit 22000 tons of Co2, 2000 tons of nitrogen oxide, 4000 tons of hydrocarbon and 333.3 tons of sulfur dioxide and particles per annum (Dhamala, 1983).

Furthermore, the content of lead in the dust has been increasing due to the increased movement of vehicles. Vehicular movements of more than 2000/day have contributed nearly 300 ppm. According to some estimate, the lead content/square foot at Maitighar, Central post office and Narayanhiti crossing points were 574, 374 and 323 ppm respectively. The vehicular movements on these points were 2200, 2000 and 166/day respectively (Shrestha and Bhattarai, 1980). Primarily, increased amounts of lead were due to auto exhaust fumes for there were no other sources reported to produce lead particles. These toxic particles are carried by air and ultimately find their way to settle on the open field, on plants or in the water of the surrounding area.

Evaluation of the noise and air pollution in Kathmandu

Heavy traffic flow along the too narrow streets and the use of a large number of old vehicles are the potential sources of the air and noise pollution in Kathmandu. The lack of proper traffic regulations, concentration of compact buildings, lack of sufficient green elements, very bad streets and haphazard location of parking spaces have worsened the situation in such a way as to make it alarming. With a view to provide a general picture of this issue, a general map has been prepared on the basis of the available literature and personal experience. As a matter of fact, this map is not based on the absolute measurement of the noise of the territory. However, the evaluation is based on the structure of the road networks, traffic flow situation and the number of the automobiles used in the particular streets.

This map has been prepared after the analysis of the following parameters:

- Traffic flow intensity;
- Quality of the roads;
- Width of the streets;
- Compactness of the buildings and population density;
- Abundance of the green elements in the studied area.

Moreover, the assessment of these parameters is based on the following criteria on the table 20:

A.	Traffic flow	...	7	low
		...	8	medium
		...	9	high
B.	Quality of the streets	...	1	relatively good
		...	2	medium
		...	3	bad
C.	Width of the streets	...	4	relatively broad
		...	5	narrow
		...	6	too narrow
D.	Compactness of the buildings and population density	...	12	low
		...	13	medium
		...	14	high
E.	Abundance of the green elements	...	10	with
		...	11	without

All the analytical maps containing the fixed value (e. g. 1, 4, 7, 10, 13) have then been made ready for synthesis. These values obtained after synthesis were codified, evaluated and are illustrated in Table 20.

*Tab. 21: Landscape - ecological evaluation of air and noise pollution **

No.	**Traffic flow**	**Street quality**	**Width of street**	**Compactness of buildings**	**Abundance of green elements**	**Traffic flow**	**Street quality**	**Width**	**Compactness of buildings**	**Green elements**	**Degree of pollution**
1	7	1	4	12	10	G+	G	G	G	G	very low (1)
2	7	1	4	12	11	G	G	G	G	B	
3	7	1	5	12	11	G	G	M	G	B	
4	7	3	6	12	10	G	B	B	G	G	low (2)
5	7	3	6	12	11	G	B	B	G	B	
6	8	1	5	12	10	M-	G	M	G	G	medium (3)
7	8	1	5	12	11	M	G	M	G	B	
8	8	1	5	13	11	M	G	M	G	B	
9	8	1	5	13	11	M	G	M	M	B	
10	8	1	5	14	11	M	G	M	M	B	
11	8	1	6	12	10	M	G	B	G	G	
12	8	2	4	12	11	M	M	G	G	B	
13	8	2	5	12	10	M	M	M	G	G	
14	8	2	6	13	11	M	M	B	M	B	
15	8	3	5	12	11	M	B	M	G	B	
16	8	3	6	12	10	M	B	B	G	G	
17	9	1	4	12	10	Bx	G	G	G	G	high (4)
18	9	1	4	14	11	B	G	G	B	B	
19	9	1	4	12	11	B	G	G	G	B	
20	9	1	5	12	10	B	G	M	G	G	
21	9	1	5	12	11	B	G	M	G	B	
22	9	3	6	12	11	B	B	B	G	B	very high (5)
23	9	3	5	13	11	B	B	M	M	B	

G+ = relatively good
** The properties of the selected parameters are expressed in the five place codes.*
M- = middle
Bx = relatively bad

5.5.2 Delimitation of areas with urban land use conflicts

The pressure of urbanization in Kathmandu is very high. Uncontrolled population growth, migration, bias infrastructural development, increasing attraction towards tourism development etc. are making the city environment more unhealthy and unsuitable.

The 'tar' lands are the most suitable site for future development. However, there is little chance for future infill and building processes. When all the flat lands (tars) are occupied, then a tremendous pressure on the 'dol' lands can be expected and if these flood lands (alluvium) are not preserved, the ecological balance of the whole city will be disturbed.

With a view ot minimize the potential landscape-ecological risk, a suitability map of this planned territory has been prepared for the growing needs of urbanization processes. The suitability map was prepared after the evaluation of various parameters such as geomorphology, angle of slope, soil condition etc. After the evaluation of these parameters, we were able to categorize the agricultural land into A1, A2 and A3.

Besides the evaluation of the landscape-ecological potential of this territory for arable land, other factors, i.e. ecological and socio-economic factors were also taken into consideration and the areas were delineated with different levels of landscape-ecological risk and future expansions can be encouraged in those areas where the potential landscape-ecological risk is very low.

The urban land use conflicts were prepared on the basis of the following classification and evaluation scheme.

Parameter 1. Landscape-ecological potential of the territory for arable land:
- high (landscape-ecol. potential unit A1)
- medium (landscape-ecol. potential unit A2)
- low (landscape-ecol. potential unit A3)

Parameter 2. Landscape-ecological risk for the built-up areas:
- high (combination of 2 natural limiting factors)
- medium (1 natural limiting factor)
- low (without natural limiting factor)

By the cartographic overlay of the above mentioned parameters, a synthetic map was prepared. This map was prepared for the landscape-ecological suitability of arable land for the expected urbanization. The map shows the following degrees of suitability:
- very small landscape-ecological suitability
- small landscape-ecological suitability
- medium landscape-ecological suitability

Parameter 3. Land value (in thousand Rupees per ropani)
- high (65 – 85 R/r)
- medium (45 – 65 R/r)
- low (15 – 35 R/r)

Parameter 4. Density of population (persons/hectare)

- low (50 persons/ha)
- medium (51 – 100 persons/ha)
- high (more than 100 persons/ha)

Parameter 5. Accessibility of the territory:

- bad (without infrastructure, i.e. roads, electricity, water, etc.)
- medium (partly existing facilities)
- good (sufficient facilities)

Fig. 7

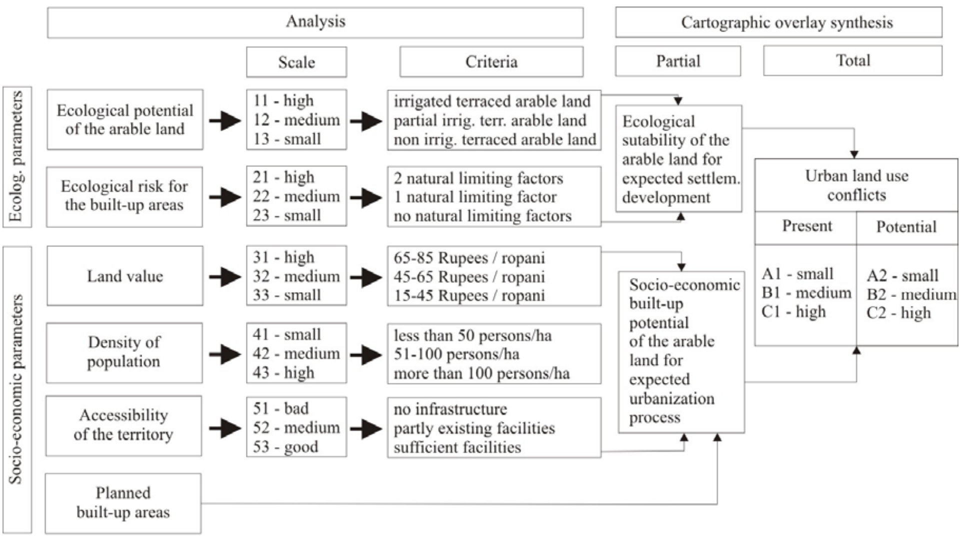


Fig. 7 Delimination of areas with urban land use conflicts

By the combination of the above mentioned socio-economic parameters 3,4,5, the following table 22 was prepared:

		Land value	**Population density**	**Accessibility**
Expected urbanization process	low	high	low	bad
	medium	medium	medium	medium
	high	low	high	good

By the confrontation of the landscape-ecological suitability of the arable land with the socio-economic limiting factors (parameters) of expected urbanization processes, the following classes of urban land use conflicts have been identified:

- small conflict,
- medium conflict,
- high conflict.

Moreover, the final map (conflict map) was compared with the proposed land use map (1:20,000) prepared by the Kathmandu Valley Town Planning Team (1984) and the projected urban expansion in Kathmandu Valley prepared by PADCO, 1985. The results are expressed on conflict map.

5.5.3 Measures for landscape protection and creation

Measures for landscape protection and creation is the fundamental aspect of landscape-ecological planning. Its main object is to identify the main problems (environmental) and to suggest some measurements for the improvement of the environment of the planned territory. Moreover, its main object is also to prepare a map for landscape creation and protection. However, this map was prepared on the following areas:

- All the terrace edges are most suitable sites for landscape creation. Population pressure on these potential sites is very high and most of the terrace edges are occupied by buildings. It is not possible to create a new landscape on all terrace edges. It is, therefore, necessary to select those areas which are moderately to steeply sloping. These sloping terraces are then provided with greenery elements.
- Most of the river banks which lack barriers are protected by water tolerant trees.
- Depending upon the possibility of site, demands, hazards, some transportation networks are provided with some trees and other greenery elements.
- Some vacant, unused and unsuitable land for other functional elements is selected for landscape creation.
- Fallow land near the airport is selected for afforestation.
- Airport area (around runway) is delineated with compact vegetation.
- All remaining forests and greenery elements were not changed in any case but they are supported, protected and conserved for the future needs of society.

5.5.4 Recommendations

The objective of LANDEP is to provide a framework for a well-balanced socio-economic and ecological development by allocating land and other resources for the particular functional elements of the territory.

In order to achieve a sound and realistic planning, an in-depth knowledge of the physical factors as well as socio-economic conditions is essential to bring out its future potentials and limitations for development. In the absence of a comprehensive survey, analysis and evaluation concerning the physical potentials and socio-economic aspects of the region, there could not be any effective planning resulting in a higher quality of the environment as a whole. However, if the information is relevant and the required analytical maps are prepared with accuracy, there will be little chance of failure for the proposed landscape-ecological planning of the territory.

At present, the available information regarding texts, data, reports and maps is very limited. Whatever information is provided by ongoing projects, studies and surveys shows great controversy and thus an unreliable picture. It is therefore necessary to carry out future projects, programs and and studies in the following fields accompanied by cartographic material:

- Preparation of the base map. It is recommended that a detailed base map with special emphasis on topography and a city map of Kathmandu City should be prepared at the scale 1:10,000 or 1:50,000. The present city map (i. e. city map no. 1., scale 1:10,000) as prepared by the Survey Department, Topographical Survey Branch, HMG/N is inadequate and inaccurate to some extent. The map should be reviewed, corrected and more information can be provided after a detail survey and field checking.
- Preparation of the soil map Two main reports on the soil have been prepared by the FAO (General Soil Survey of Bagmati and Narayani, 1974) and LRMP (LRMP Land System Report, 1986). The FAO report provided a soil map which is too general and it is very difficult to draw a definitive conclusion for delineating the particular soil unit within a small territory such as Kathmandu City itself.
- The LRMP Land System Report has tried to provide more information about the occurrence of different great groups of soil. There are characteristic features, but there is a lack of an analytical soil map with exact delineation. Moreover, both reports reveal a contradictory picture about the occurrence and features of the soil. As a matter of urgency, a detailed soil map has to be prepared after the field survey and the laboratory analysis. Special emphasis should be put on the soil permeability, soil texture, drainage factor, moisture regime, vegetation, water table etc.
- Preparation of the vegetation map The analysis and study of the vegetation, its quality, quantity, its location and distribution could play an important role in the landscape protection and creation in Kathmandu. Moreover, open space planning (gardens, parks, greenbelts etc.) for the future needs of the different parts of the city could not be fulfilled in the absence of a general survey of the particular plant species.
- Their abundance and distribution is determined by many factors such as rainfall, relative humidity, temperature, land use intensity etc. For example, plants which can thrive in an aquatic environment may not grow in a terrestrial environment. In the same way, some water-tolerant plant species could only be planted in a flood-sensitive area. A list of exotic and endemic floral species occurring along river channels, agricultural fields, in forests and settlements must be prepared for future planning purposes.
- Preparation of a geohydrological map the available information suggests that the potential underground sources of water are limited. Moreover, the quality of water is extremely corrosive and mixed with hydrogen gas. Water supplied for drinking purposes is also far below than adequate standard. It is, therefore, essential to prepare a detailed geohydrological map provided with sufficient information about the depth of the underground water table. This geohydrological map could be used for interpreting and evaluating the potential danger of underground water pollution and, therefore, future activity could be proposed in those areas which show little risk of potential water pollution.

- Preparation of the land tenure map There exist five types of landownership in the planned territory: government, public, private, private guthi and guthi corporation owned. Among those types, private land is the dominant tenure form and occupies the greater part (approx. 90% of the cultivated land) and unlike government, public and guthi lands, private lands are subject to land revenue, property and compound tax. As a matter of fact, government land and especially guthi land would provide a basic framework for the future planning and decision making processes. However, the lack of a tenure map with exact boundaries, sizes and locations have made landscape-ecological planning in Kathmandu a difficult task. In addition to government and publicly owned land, guthi lands appear to be the most preserved and safe lands whose ownership or output will only be transferred to charitable, religious or philanthropic institutions. A recent study (Padco, 1986) suggests that most guthi lands (approximately 7,293 ropani) are found in the proximity of the planned territory. Moreover, the guthi lands provide a great potential site for the desired planning and development of Kathmandu. Because of those facts

(a) guthi lands could be used for the desired landscape creation (parks, greenbelts, gardens and other open space),
(b) guthi land could serve as a buffer zone between the built-up and the non-built-up areas,
(c) guthi land could be preserved easily, and
(d) guthi land could be used for any other developmental purpose.

It is, therefore, recommended that a land tenure map with special emphasis on guthi land should be prepared urgently.

Due to personnel and financial restrictions this study had to limit itself to Kathmandu City. In order to arrive at a more complete picture of the desirable development of the valley, it is necessary to prepare another integrated study on the Kathmandu Valley as a whole.

In addition to the above mentioned recommendations, the following areas should be provided with sufficient information accompanied by cartographic material:

- Location, size, the present state and function of the fallow land;
- Availability of open space and parks for recreation;
- Impact of the major sectoral projects;
- Proposed extension and improvements of infrastructural facilities (roads, drainage, water, electricity etc.);
- Major sources of fuel wood and the amount of fuel wood consumed in the urban center;
- Adequacy of public health facilities and endemic disease prevention;
- Problems of slums and their remedies.

5.5.5 *Application fields of the study*

The result of this study ”Landscape-ecological Planning for Kathmandu City” can be applied to:

1. The delimitation of priority areas for agricultural fields, settlement, industry, forestry, nature protection etc. (see Fig. 8).
2. The results could supply basic background material for the projects, teams and other organizations. They are:
   - Kathmandu Valley Physical Development Team
   - Environmental Impact Study Project
   - Nepal/Australian Forestry Project
   - Solid Waste Management Project
   - Resource Conservation and Utilization Project.
3. The assessment and evaluation of the present day land use in the planned territory.

Fig. 8: Spatial Functions and its Consequences for Planning in Kathmandu

Human Activity/Function	Cultural Elements	Importance for the Landscape-Ecological Planning
Housing/Residential/ Monumental/Institutional	Palaces/ - Pagodas Temples Stupas Shikarra	Core of the Future Protective Zone of Natural and Religion Areas
Agriculture	Irrigated Terraces/ Non Irrigated Terraces Guthi Land	Core of the Future Ecological Corridors for the Animals and Vegetation Core of the Future Buffer Zones between the Built-Up-Areas and Non-Built-Up-Areas
Recreation and Forestry	Open Space/Parks	Core of the Future Zones with Green Elements