The integration of urban biotope mapping in spatial planning

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Abstract

The South African Government has made significant efforts towards integrating the concepts of environmental sustainability with spatial planning. This article focuses on the integration of spatial planning at municipal level with the zoning of land in terms of ecological aspects, including biodiversity. Currently, Spatial Development Frameworks are being compiled at local and district municipal levels as a legal instrument to guide future spatial development. Although it forms part of an integrated approach, i.e. most relevant sectors made a contribution in this regard (through the Integrated Development Planning process), it has shortcomings specifically with regard to environmental matters. Greenfield developments are subjected to Environmental Impact Assessments in most cases where agricultural land is redeveloped. In brownfield developments, however, the land only needs to be rezoned properly – in most cases without an Environmental Impact Assessment. The Impact Assessment is, therefore, a reactive instrument to protect the environment. Strategic Environmental Assessment guidelines, i.e. a pro-active instrument, are quite complex and expensive processes; with little legal backing and support at the moment. On the other hand, biotope mapping is used in numerous countries in Europe as an effective instrument to guide spatial planning and land use management at municipal level. A biotope is an ecological concept and denotes an area that is characterised by specific biota, certain environmental conditions and clearly linked to past and present land-uses. The first phase of integration of these instruments, i.e. biotope mapping and spatial planning, has been implemented in the Potchefstroom Local Municipality as part of the formulation and promulgation of the Spatial Development Framework. This article shows the process and results of the integration process.

Keywords: Spatial planning; biotope mapping; Spatial Development Framework; Strategic Environmental Assessment; ecological diversity; Potchefstroom.

DIE INTEGRASIE VAN STEDELIKE BIOTIPE KARTERING IN RUIMTELIKE BEPLANNING

Die Suid-Afrikaanse Regering het reeds betekenisvolle pagings aangewend opsigte van die integrasie van die konsepte vir omgewingsvolhoubaarheid by ruimtelike beplanning. Hierdie artikel fokus op die integrasie van ruimtelike beplanning op munisipale vlak met die sonering van 'n gebied in terme van die ekologiese aspekte, insluitende biodiversiteit. Tans word Ruimtelike Ontwikkelingsraamwerke op plaaslike en streeksvlakke saamgestel om as wetlike instrumente te dien vir toekomstige ruimtelike ontwikkeling. Hoewel dit 'n deel uitmaak van 'n integrale benadering en die meeste relevante sektore 'n bydrae maak in dié opsig (deur middel van die Geïntegreerde Ontwikkelingsbeplanningsproses), is daar steeds sekere tekortkomings ten opsigte van omgewingsake. Groenstrook-ontwikkelings is in die meeste gevalle onderhewig aan Omgewingsimpakstudies wanneer landbougrond herontwikkel word. In die geval van "brownfields", daarenteen, hoef die grond net behoorlik gehersoneer word – meestal sonder dat 'n omgewingsimpakstudie gedoen word. Die studie is hiervolgens net 'n reaktiewe instrument om die omgewing te beskerm. Strategiese omgewing-studieriglyne, as 'n proaktiewe instrument, is uiters komplekse en duur prosesse wat tans min of geen geregtelike steun of bystand het nie. Aan die anderkant, word biotipe kartering reeds in etlike Europese lande op munisipale vlak as 'n effektiewe instrument ingespan vir riglyne by ruimtelike beplanning en grond-bestuur. 'n Biotipe is 'n ekologiese konsep wat 'n aanduiding gee van die biotipes in 'n area, sekere omgewingstoestande en wat duidelik verbind kan word met vorige en huidige grondgebruike. Die eerste fase van integrasie van hierdie instrumente, d.i. biotipe kartering en ruimtelike beplanning, is deur die Potchefstroomse Munisipaliteit geïmplimenteer as deel van die formulering en proklamasie van die Ruimtelike Ontwikkelingsraamwerk. Hierdie artikel gee 'n aanduiding van die integasieproses en die resultate wat die integrasie opgelewer het.

1. INTRODUCTION

Since the lifting of migration-controlling legislation and policies in South Africa in the early-1990s, urbanisation levels have seen a significant increase throughout the urban system of South Africa (Saff, 1994:378). As South Africa is characterised by a significant Third World socio-economic component, whereby a large share of the population is settled in so-called rural areas, the strain on the urban structure is probable to increase significantly in the medium term (Mouton, 2003:10). The urbanisation rates for the large South African cities are also higher than in the rest of the urban hierarchy (Borraine, 2004; Dewar 2000:170-175). In this regard, the country compares with numerous developing countries throughout the world suffering from high urbanisation rates, combined with increasing population growth (UNDP, 2002:13).

The spatial implication of urbanisation forms a vital focus in this study. Urbanisation in South African cities is primarily exacerbated by urban sprawl and intensification (Todes, 2003:118; Pieterse, 2003:131). With regard to the former, it is still common practice in numerous municipalities to facilitate low-cost housing on greenfield developments on the periphery, i.e. on agricultural or natural habitats. The latter scenario, i.e. intensification through mixed land use and multi-functional zoning is facilitated mainly through the development of former buffer zones and open space in an effort to integrate urban zones (Williams, 2000:176; Lemon, 2003:209). The practical realisation of the Government's objective of urban transformation and integration (DLA, 1995, 1997; OP, 2000), therefore, has a significant affect on the natural environment enclosed within and surrounding the built-up cities.

For at least the past decade, the destruction of natural vegetation within and around South African cities has been taking place at an alarming rate and immense areas of ecologically significant open space are cleared for persistent urban growth (Cilliers, 1998:407). It has also been shown to be essential that

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GO KOPANGWA GA MMEPE WA BIOTOPE DITOROPONG MO MERALONG YA DIBAKA

Puso ya Afrika borwa e dirile maiteko a botlhokwa go leka go kopanya dikakanyo tsa tikologo tse di tswelelang le meralo ya dibaka. Lekwalo le, le lebelela go kopangwa ga meralo ya ntlefatso mo maemomg a bomasepala le tiriso ya lefatshe e e tsenyeletsang tikologo le tlhago. Mo sebakeng sena, meralo ya tsweletso le ntlafatso (SDF) e dirilwe ke masepala wa selegae le sedika jaaka didiriswa tsa semolao go bontsha bokamoso jwa meralo ya tsweletso. Le ha ele karolo ya leano le le kopaneng le le dirisiwang, i.e. bontsi jwa mafapha a a maleba a thusa ka motlhala wa (leano la masepala la tsweletso le ntlefatso (IDP), e nale mathatha fa go tliwa mo go tsa tikologo, fa go dirwa teko ya tikologo le tlhago mo mabakeng a mantsi mo lefatsheng *la temothuo le le tshwanetseng go tsweletsa gape. Kwa tsweletsong ya brownfield,* lefatshe le thloka dirisetswa tiro e e maleba – mo mabakeng a mantsi kwantle ga teko ya tikologo le tlhago. Teko e, ya tikologo le tlhago e dirisiwa jaaka sedirisiwa se se sireletsang tlhago. Matlhale a a bontshang go sekaseka le go sireletsa tikologo, i.e. a *dirisiwa jaaka didiriswa tse di thibelang mme ga di bonolo le gona di thloka tshelete* e ntsi; di tlhoka lemorago la semolao le kemo nokeng ka nako ena. Mmepe wa biotope o dirisiwa mo dinageng tse dintse tsa Uropa jaaka sediriswa se se tlhomameng go bontsha meralo ya dibaka le tiriso e e lolameng mo maemomg a bomasepala. Biotope ke kakanyo ya tlhago e e bontshang tulo kapa lefatshe le le naleng biota, go nale maemo a tikologo a a tlhagalelang sentle mme a kgone go bontsha tiriso ya lefatshe gompieno le maloba kapa nako e e fetileng. Karolo ya ntlha ya go kopanya didiriswa tse, i.e. mmepe wa biotope le meralo ya dibaka, di dirisiwa ke masepala wa Potchefstroom jaaka karolo ya meralo ya tsweletso le ntlafatso mme di tsenyeletsa tsela e di tla kopangwang ka yona.

environmental protection that includes nature conservation be improved in urban areas (Cilliers *et al,* 2004:49-62). Accordingly, there should be a shift from protection of only particular species of interest towards the preservation of functioning natural communities, the maintenance of maximum sustainable biotic diversity and the minimisation of extinction (Roberts, 1990:148-188; Cilliers, 1998:401-406; Verster, 2002:66). Urbanisation is a major additional influence, second only to agriculture, on the loss of natural areas in the Grassland Biome of South Africa (Low & Rebelo, 1996:38).

2. POLICY ISSUES

Since the 1980s, many countries developed programmes specifically for sustainable urban development (Breheny & Rookwood, 1994:155; Mahadevia, 2001:242). The United Nations Habitat conferences in 1992 (Rio de Janeiro) and 1996 (Istanbul) enforced the efforts on nature conservation and sustainable development in cities (Müller, 1997:47-62). At the Rio-Conference, the advancement of sustainable development of human settlements, focusing on the improvement of the ecological, economical, cultural and social conditions, was confirmed (UNDP, 1996; Mahadevia, 2001:245). Bearing in mind the changes that took place and will influence spatial development in South Africa in future (Saff, 1994:389; Williams, 2000:168), local planning strategies of urban areas should differ markedly from those of European and North American cities (Harrison, 2001:178). Hindson (1994) reported from the Global Forum '94 that it was clear that the major concerns of countries in the northern hemisphere were over issues such as conservation, biodiversity, energy efficiency and rehabilitation of damaged landscapes. Countries in the southern hemisphere regarded issues such as poverty, equity, redistribution of wealth and wealth creation, as more important (Hindson, 1994:3-7).

In spite of this tendency in Third World Countries, a number of positive efforts were made in South Africa to incorporate environmental issues in the form of legislation aimed at development in urban areas. The Reconstruction and Development Programme (ANC, 1994), the Urban Development Strategy (DOH, 1995), the Rural Development Strategy (DLA, 1997) and the White Paper on Spatial Planning and Land Use Management (MALA, 2001) all stressed that sustainable urbanisation must be part of the process of post apartheid-reconstruction. However, in an analysis of the role of botanists in the Reconstruction and Development Programme, Low (1995:11-12) emphasised the need for empirical research into the nature, survivability and biodiversity of remnants of natural areas in the urban environment, as well as of investigations into the potential role of these areas as community reserves.

The Development Facilitation Act (Act 67 of 1995) (DLA, 1995) introduced extraordinary measures to facilitate and speed up the implementation of reconstruction and development programmes in relation to land. This Act laid down general principles governing land development throughout the country – one of which was that all new development had to be environmentally sustainable (DLA, 1995:7). Other relevant legislation that was passed shortly afterwards, include the Environment Conservation Act (Act 73 of 1989), whereby the environmental impact had to be determined before new urban development could take place, especially with regard to public and private parks (DEAT, 1987). In addition, the National Environmental Management Act (Act 107 of 1998) made provision for the compilation of Strategic Environmental Assessments[1] in urban areas, although it is not compulsory to do so (DEAT, 2000:10).

On the spatial planning side of the coin, urban and regional planning policy and practice have traditionally distinguished between 'forward planning' and 'planning control' (MALA, 2001:12). These approaches relate to the application of spatial planning at the different government levels, but especially on local and metropolitan levels. "Forward planning" as such aims at earmarking undeveloped land for various purposes, whether it be residential expansion, bulk infrastructure, open space or even conservation in its existing state. On the other hand, planning control refers to the management of land, especially in urban areas (i.e. by means of land use management schemes). The focus at this stage of the research, and specifically in this paper, relates to "forward planning" or spatial planning.

Recently, spatial planning and sustainable development have moved closer to a more integrated approach as essential components of Integrated Development Planning (IDP), i.e. a strategic management process that is formulated on the local and district government levels as prescribed by the Municipal

[1] A Strategic Environmental Assessment is regarded as a process to assess the environmental implications of a proposed strategic decision, policy plan, programme, piece of legislation or major plan (DEAT, 2000:9).

Systems Act (Act 32 of 2000; OP, 2000). The IDP forms the "... centrepiece of planning in post-apartheid South Africa [...] intended to provide strategic guidance to newly constructed municipalities, and to link and co-ordinate the many different sectoral plans and planning processes" (Harrison, 2001). According to the Municipal Systems Act, formal spatial planning must be facilitated by Spatial Development Frameworks (SDFs) as part of the IDP. A Spatial Development Framework forms the main instrument whereby all future spatial development should be guided at municipal level (local and district) and is enforced by law once accepted by the relevant Provincial Government (see Section 32 of Act 32 of 2000). A Spatial Development Framework should, according to the White Paper on Spatial Planning and Land Use Management (MALA, 2001:15), consist of four components:

- a policy for land use and development;
- a Strategigic Environmental Assessment;
- guidelines for land use management; and
- a capital expenditure framework.

The interpretation of the first two principles refers to the identification of focus areas for the conservation of natural environments, as well as for the identification of areas where specific land use types must be encouraged or discouraged. To facilitate these principles, the Urban and Regional Planner must translate these principles and guidelines into a practical plan to guide future development of the relevant municipality in a sustainable manner. If one looks at the relevant environmental legislation and policy to provide such guidance, a number of documents are relevant. According to the Environmental Conservation Act, (DEAT, 1989), sustainable development includes the following relevant criteria:

- the conservation of ecological processes and biotic diversity;
- the sustainable use of species and ecosystems; and
- the development of acceptable social environments.

The National Environmental Management Act (OP, 1998) argues that sustainable development in this context would *inter alia* include:

- that the disturbance of ecosystems and loss of biological diversity be avoided;
- that pollution and degradation of the environment be avoided; and
- that the use and exploitation of non-renewable sources is responsible and equitable.

The problem, however, is the integration of these well-founded environmental principles with spatial planning policies and legislation. It is evident that these principles and guidelines have little or no specific reference to one another. Especially the latter environmental sustainability principles remain quite abstract in its application on local and district municipal levels. This is of significance when one considers that it is usually spatial planning professionals who are the leading agents in compiling Spatial Development Frameworks. Generally, they are not equipped to translate these concepts scientifically into tangible spatial planning documents that are used to facilitate spatial development in municipalities. As mentioned, the guidelines provided by the Department of Environmental affairs for the preparation of Strategic Environmental Assessment (DEAT, 2000) holds much promise, as it relates to the integration of spatial planning parallel to environmental guidance. This latter approach is more pro-active than the abovementioned environmental impact assessments that are only formulated after land has been earmarked or assessed for potential development.

Few municipalities have been fortunate to finance such extensive and complicated studies like strategic environmental assessments. Provincial governments and municipal authorities usually do not have the expertise to apply the legislative issues regarding conservation and management of urban open spaces. Other problems are the lack of ecological and bio-geographical data together with issues such as division of authority, public attitudes and reactions with regard to the implementation of environmentally sustainable planning and management of urban areas in South Africa (Poynton & Roberts, 1985:33-37; NWPG, 2004:2-5). Lastly, tangible and practical urban ecological and biodiversity principles or indexes that can be transferred to the planning and management process of urban and rural areas barely exist (Picket *et al., 2001*; Drewes & Cilliers, 2002). The following sections attempt to find a practical, and affordable solution to integrate these two mainstreams during the process of integrated development planning in the Potchefstroom Local Municipality.

3. STUDY AREA

Potchefstroom Local Municipality covers an area of 25 076 km^2 and includes the city of Potchefstroom, an informal settlement, Matlwang, military areas, agricultural operations and a proposed national park. It is situated along the N12 road between Gauteng and Kimberley with a total population of approximately 180 000 people (DPLG, 2001).

In terms of its ecological profile, it is situated in the western part of the Grassland Biome of South Africa (North West Province). From *Figure 1* it may seem that vast tracts of grassland still exist, but much of these have been disturbed by past cultivation, livestock grazing or the disruption of natural fire cycles, resulting in a severe decrease in plant, insect and animal species diversity. Urbanization is a major additional influence on the loss of natural areas in this biome (Rutherford & Westfall, 1994:48-50). Further vegetation destruction occurs due to industrial and mining activities (Bezuidenhout, 1993:2). Although the Grassland Biome is considered to have extremely high plant species diversity, second only to the well-known Fynbos Biome, including many rare and threatened species (Rutherford & Westfall, 1994:48-50), it is regarded as one of the most critically threatened southern African ecosystems (Siegfried, 1989).

4. URBAN BIOTOPE MAPPING

In Europe, the first projects that focused on nature conservation in and around cities, became famous as urban biotope mapping (Sukopp *et al.*, 1980; Starfinger & Sukopp 1994:47-62; Müller, 1997; Picket *et al.*, 2001:127-157). Biotope mapping was initially limited to natural landscapes and focused only on

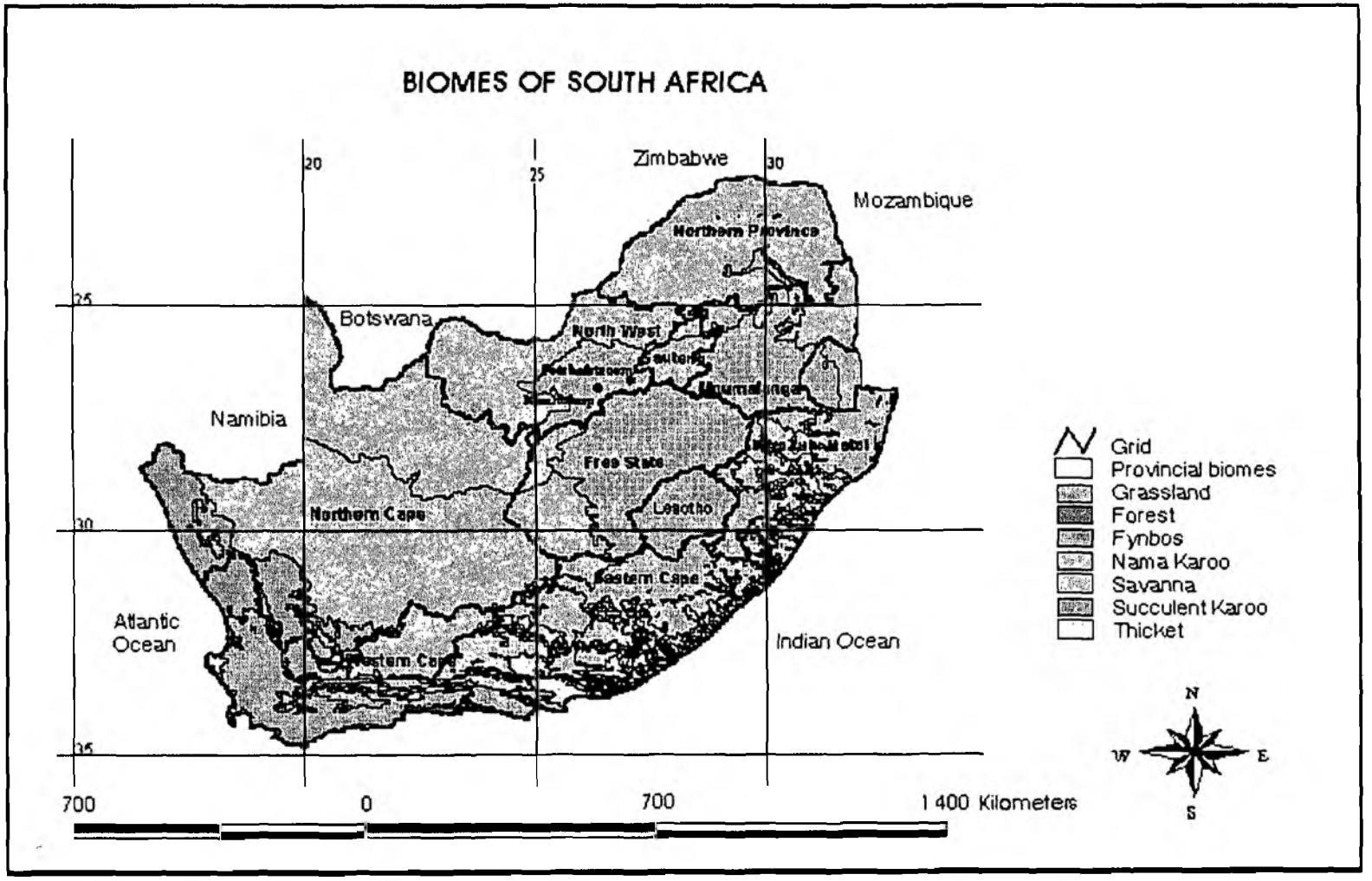

Figure 1: Biomes of South Africa (Rutherford & Westfall, 1994)

habitats for rare and endangered species (Kaule, 1975:257-260), but later developed towards the protection and establishment of nature in cities as a basis for a direct contact between urban dwellers and natural elements (Sukopp *et al.*, 1980; Starfinger & Sukopp, 1994:89-115). The term biotope has an ecological meaning according to Forman (1995) and refers to a specific area which is characterised by certain conditions and populated by characteristic biota. Löfvenhaft *et al.* (2002:223-240) chose to work with biotopes in urban planning because it is, 1) at biotope level that influences caused by changes in land-use can first be detected and, 2) biotopes are demarcated areas that can be cartographicaliy represented. Urban biotopes are, furthermore, regarded as important refuges, dispersal centres and corridors for species; for environmental protection and ecological balance (hydrological cycle, water resources and hygiene, climate, air hygiene, noise protection); for the aesthetic quality of the urban landscape, as areas for low-key recreation opportunities; as informal playgrounds for children; as demonstration and experimental areas for educational purposes; as bio-indicators for environmental changes and pollution and for fundamental research into urban ecology (Starfinger & Sukopp, 1994:39-115; Müller, 1997:47-62).

Although urban biotope mapping started in Germany, several other projects were completed in countries such as Japan (Müller, 1997:47-62), Brazil (Weber & Bede, 1998:636-640) and Sweden (Löfvenhaft *et al.*, 2002:223-240) to mention only a few. This method has not been implemented or adapted in South Africa, but can be compared to the bioregional planning methodology in the Western Cape (Canca, 2002) but on a much finer scale. A bioregion may contain one or several nested ecosystems characterised by landforms, vegetative cover, human culture and history. In bioregional planning a comprehensive set of spatial planning categories (SPCs), such as neighbourhood areas, neighbourhood precincts and special management areas are proposed (Canca, 2002:6). In general biotope mapping focused on more detailed information, such as floristic and phytosociological features as it is relatively easy to study plants in comparison with animals (Sukopp & Weiler, 1988:37-58). Similar vegetation studies have been used in bigger cities like Durban as base line data for the proposal of metropolitan open space systems (MOSS) (Coleman, 1991:10-11; Roberts, 1993). In the MOSS concept, biogeographical guidelines are emphasised. Poynton & Roberts (1985:33-37) stated that the application of biogeographical aspects needs to be done if urban open space systems are to be made ecologically resilient and diverse.

Floristic studies include an inventory of the plant species of a specific area (Jones & Luchsinger, 1986:5-9), while phytosociology refers to the identification, classification and naming of plant communities as specific assemblages of plant species (Kent & Coker, 1992:245-246). Detailed phytosociological and floristic studies in the city of Potchefstroom formed a solid basis for testing urban biotope mapping under South African conditions. These studies include the wetlands (Cilliers *et al.*, 1998:213-229), railway reserve areas (Cilliers & Bredenkamp, 1998:271-280), intensively managed parks, pavements and parking areas (Cilliers & Bredenkamp, 1999a:59-68), vacant lots in residential, commercial and industrial areas (Cilliers & Bredenkamp, 1999b: 163-173), road verges along an urbanization gradient (Cilliers & Bredenkamp, 2000a:217-239) and "natural" grasslands and woodlands (Cilliers *et al.*, 1999:1-30) in the Potchefstroom Municipal area.

In principle, two methods of biotope mapping in urban areas can be distinguished namely selective and comprehensive mapping (Sukopp & Weiler, 1988:39-58). Selective mapping investigates only areas that are regarded as worthy of protection. These areas can be defined in an urban context as those with a high vegetation cover and low influence of human impact, such as forests, shrubs, old ruderal vegetation, extensively used meadows and abandoned or extensively used allotments (Müller & Waldert, 1981:419-429). In this method, biotopes worthy of protection are those that show a typical spectrum of species on a specific site and/or a high variety of vegetation age and structure and/or development over a long time (Müller, 1997:47-62).

Comprehensive mapping investigates all land-use types such as settlements, industrial areas and waste lands (Sukopp & Weiler, 1988:39-58). Since it is not possible to carry out a highly detailed study over the entire city area, sample areas for all land-use types are chosen, in order to identify the complete spectrum of different biotope types and is called comprehensive-representative mapping (Müller, 1997:47-62). Afterwards the biotopes worthy of nature conservation are selected. Although comprehensive biotope mapping is more labour and cost intensive than selective mapping, it gives a more detailed basis for further interpretation regarding issues such as evaluation of different biotope types as dispersal corridors, selection of plants for green space planning and documentation of changes in flora and vegetation after a second investigation (Müller, 1997:47-62).

In addition to the mapping of flora and vegetation, investigations of some selected animal groups can be done by both methods of mapping. The aim is to determine which other areas, such as bare ground which is not important for conservation of plants, are valuable for the protection of the various animal groups (Plachter, 1980:569-576).

As mentioned, urban biotope mapping was never before attempted in South Africa and, therefore, a working procedure was proposed for the city of Potchefstroom (*Table 1*). One of the first tasks after consolidation of all available data was to establish a key for biotope types based on land-uses and following a hierarchical approach (*Table 1 – step 3*). Although this mapping key was based on general concepts used in Germany (Müller & Waldert, 1981), it was less complex but did include certain specific and detailed biotope types not common in European cities, such as various informal residential areas that have an immense influence on existing natural vegetation (*Table 2*). The following major biotope types were identified and mapped using aerial photographs and extensive verifications on the ground: central city (combination of other biotopes), residential, commercial, industrial, managed green spaces, man-made water bodies, traffic, agriculture,

Table 1: Proposed working procedure for urban biotope mapping in Potchefstroom

1. Selection of the investigation area

2. Verification and evaluation of available data
Literature
Historical maps
Actual maps
Aerial photos
Local experts
Land-use types (maps)

3. Preparation of the map of the biotope types
Preparing the key of the biotope types
Verify it in the field and prepare a biotope map

4. Selection of the test areas
Choosing the spectrum of representative biotope types and indicate it on the biotope map

5. Mapping the representative biotope types
Flora & vegetation
Fauna
Percentage of vegetation cover
Percentage of sealed areas
Potential of sustainable use of nature (e,g, medicinal value and other uses)
Potential for nature experience
Potential for recreation

6. Summarise and evaluate the representative mapping
Description of representative biotypes with regard to:
nature concervation
nature experience and
sustainable use
scenery
Selection of the biologically rich areas

7. Map of all biologically rich areas in the entire city

8. Transform the results into ecological city planning
Urban nature conservation
Spatial planning
Land use management

9. Repetition of mapping

plantations, natural and semi-natural, disposal sites and ditches, waste grounds, special land-use types such as military areas and schools (Rost, 2002; Röthig, 2002). Each one of these biotope types was further divided into specific and detailed biotope types as can be seen in *Table 2*.

In the selected areas of each specific and detailed biotope type an extensive array of information was gathered (*Table 1* – steps 4 and 5). Firstly more information about the biotope type regarding specific location, size, human disturbances (e.g. sealed areas, chemical influences, foreign plants, traffic, noise, recreation, eutrophication, destruction of natural vegetation, etc.), use influences of adjacent areas (no use, construction work, traffic/parking, public green areas, house gardens, etc.) was gathered (Rost, 2002; Röthig 2002). Secondly, a list of all plant species present was completed, with the focus on issues like whether it is indigenous, being threatened, a declared weed, or whether it can be used as traditional medicine, food, fire wood, for construction work and for other skills and crafts. All these aspects regarding the species are important in determining the potential land use type of each biotope type and their levels of current and future human affects that are all extremely important in conservation oriented planning and management within and around urban development. The remaining proposed steps in urban biotope mapping (see *Table 1*), should lead towards integration with spatial planning

5. INTEGRATION OF ECOLOGICAL INFORMATION INTO PLANNING

The promulgation of the Municipal Systems Act (32 of 2000) saw the compilation of Integrated Development Plans for the first time in the country. Although an environmental management strategy was compiled as part of the Integrated Development Plan (Maxim Planning Solutions, 2002) it presented the Spatial Development Framework with insufficient information to guide spatial development for the next five years. As required by the relevant guidelines (MALA, 2002), a Spatial Development Framework must include at least the components mentioned in *Section 2* (*Figure 3*), and in the study area, the main

Table 2: Mapping key for biotope types based on land-use and vegetation types developed for Potchefstroom

Major land-use types	Specific biotype types	Further detail
1. Central city (commercial/residential)		
2. Residential areas	2.1 Blocks of flats	2.1.1 Closed (no/small gardens, 70-100% sealed) 2.1.2 Open (larger gardens, <60% sealed)
	2.2 Townhouses (>one unit per plot, one small garden per unit)	
	2.3 Large single houses, parklike gardens (trees, shrubs, small lawns, flowerbeds)	2.3.1 Large gardens, <30% sealed 2.3.2 Small gardens, 30-50% sealed
	2.4 Small single houses, basic services, small gardens (few trees, shrubs, small lawns)	2.4.1 Sealed areas <50% 2.4.2 Sealed areas >50%
	2.5 Small single houses, reduced basic services (water, sewage), gardens small/absent	2.5.1 Permanent houses with electricity 2.5.2 Temporary houses without electricity
3. Commercial areas	3.1 Predominantly sealed surfaces (>70%)	
	3.2 Lesser sealed surfaces (<70%), with intensively managed green spaces	
	3.3 Lesser sealed surfaces (<70%), with extensively managed green spaces, including small wastegrounds	
4. Industrial areas	4.1 Predominantly sealed surfaces (>70%)	
	4.2 Lesser sealed surfaces (>70%), with intensively managed green spaces	
	4.3 Lesser sealed surfaces (<70%), with extensively managed or unmanaged green spaces, including small wastegrounds	
5. Managed green spaces	5.1 Intensively managed public parks (mowing >10 x per year)	5.1.1 For passive recreation 5.1.2 For active recreation (with playing apparatus, trim park)
	5.2 Extensively managed public parks (mowing usually 3-4 x per year)	5.1.1 For passive recreation 5.1.2 For active recreation (with playing apparatus, trim park)
	5.3 Private park-like open spaces (gardens of University, College, Agricultural College)	
	5.4 Sport fields and grounds	5.4.1 Predominantly sealed surfaces (>ca. 70% (tennis courts, athletic and hocky field with synthetic surfaces) 5.4.2 Lesser sealed surfaces (<ca . 70%) (cricket, rugby, soccer fields) 5.4.3 Informal sports fields (mainly soccer, baskerball, netball) on bare ground
	5.5 Cemetries	
	5.6 Camping sites	
	5.7 Botanical garden	

(table continues on page 22)

Major land-use types (continue)	Specific biotype types	Further detail
6. Man-made waterbodies	6.1 Lake (dam)	
	6.2 Ponds	
	6.3 Channels	
7. Traffic areas	7.1 Railway areas	7.1.1 Outside stations 7.1.2 Stations
	7.2 Roads	7.2.1 Main roads/highways with green verges (including traffic circles and islands 7.2.2 Local roads with street trees 7.2.3 Local roads without green verges 7.2.4 Unsealed local roads (dirt roads) 7.2.5 Parking areas 7.2.6 Trails (foot paths)
	7.3 Airstrips and hangars	
8. Agricultural areas	8.1 Crop fields	
	8.2 Sown pastures	
	8.3 Vegetable gardens	
9. Plantations	9.1 *Eucalyptus* dominated plantations	
	9.2 Others	
10. Natural and semi-natural areas (usually not mown)	10.1 Wetlands	10.1.1 Rivers 10.1.2 Streams 10.1.3 Marshes and vleis 10.1.4 Channelled rivers and streams
	10.2 Grasslands (less than 10% woody species	10.2.1 Sandy grasslands 10.2.2 Rocky grasslands 10.2.3 Clayey grasslands
	10.3 Woodlands	10.3.1 Dominated by trees 10.3.2 Dominated by shrubs
11. Disposal sites and ditches	11.1 Household disposal and building rubble sites	
	11.2 Industrial disposal sites	
	11.3 Gravel ditches	
12. Waste-grounds	12.1 Annual and biennial communities	
	12.2 Perennial communities	
13. Special land-use types	13.1 Military areas	
	13.2 Schools (ornamental gardens and sport fields)	

components of the Spatial Development Framework were as follows (Maxim Planning Solutions, 2002):

- a guide for the establishment of an effective urban structure;
- a guide for decision making as far as land uses and investment in infrastructure is concerned;
- to ensure the establishment of a stable and attractive urban environment; and
- to create an attractive environment for investment.

Against the background of this spatial planning process, the research conducted for this paper was planned in such a manner as to fit into the Integrated Development Planning process, and as such in the formulation of a final Spatial Development Framework. Potchefstroom is a secondary city in terms of size and function, and struggles with typical issues like urban integration and urban sprawl, lack of sufficient bulk services and housing (see *Figure 3*). However, it also boasts unique features in terms of cultural heritage, open space and ecologically sensitive areas.

The information gathered during the biotope mapping process was used to determine the worthiness of each specific biotope type for conservation purposes (*Table 1* – steps 6 & 7).

Table 3: Key for evaluation of specific biotope types regarding as worthy of protection in selected cities in the North West Province, South Africa (Rost, 2002; Röthig, 2002)

Evaluation criteria		**1**	**2**	**3**	**4**
Species richness (plant species)	(x1)	<60	61-80	81-100	>100
Area (m^2)	(x1)	100-200	200-500	500-1 000	>1 000
Sealed area (%)	(x1)	100-75	75-50	50-25	<25
Networking of biotopes	(x1)	None/isolated	Few	Moderate	High
Protected plant species "Red List" (Hilton-Taylor, 1996)	(x1)	None	Insufficiently known + No longer threatened	Rare + Indeterminate	Endangered + Vulnerable
Plant structural diversity	(x1)	1 Level	2 Levels	3 levels	Mosaic
Age	(x1)	0-2	2-10	10-50	>50
Estimated expenses to restore this biotope type	(x2)	Low	Average	High	Not restorable
Indigenous plants (Arnold & De Wet, 1993)	(x3)	0-10	10-30	30-50	>50
Declared weeds and invaders	(x1)	>10	2-10	0-2	0

Sum of worthiness

- 13-22 Points ⇒ Low ecological value
- 23-32 Points ⇒ Moderate ecological value
- 33-42 Points ⇒ High ecological value
- 43-52 Points ⇒ Very high ecolgical value

Each representative area received a score based on evaluation criteria (*Table 3*) based on information gathered during the mapping phase (Table 1 – step 5) and were classified as areas with low, moderate, high or very high ecological value (Rost, 2002; Röthig, 2002). Most of the areas with very high ecological value include specific rocky grasslands and wetlands that were shown in the phytosociological studies (Cilliers *et al.*, 1998:213-229; 1999:1-30) to be similar to natural areas. Five different maps were constructed for the city of Potchefstroom which include: 1) all the biotope types (including the specific and detailed biotope types as mentioned in *Table 2* (*Figure 2*), (2) the representative areas studied of each biotope type, 3) the worthiness of biotope types for nature conservation (*Figure 2*), 4) major disturbances in all biotope types, and 5) proposed measures for development and conservation such as identification of connectivity and buffer zones (Rost, 2002; Röthig, 2002).

The main findings of the biotope mapping process are shown in *Figure 2*. The relevant ecological priority areas were then integrated into the relevant Spatial Development Framework. *Figure 3* shows the areas of high and very high ecological value, based on the above-mentioned scientific process and observations. Accordingly, these areas were overlaid on the draft Spatial Development Framework and consequently revised to integrate the biotopes worthy of protection (i.e. with ecological values higher than 33 – see *Table 3*). Using Geographical Information Systems overlaying techniques, an 'ecologically acceptable' Spatial Development Framework (*Figure 4*) was generated and approved by Local and Provincial Government.

Apart from standard prerequisites of a Spatial Development Framework (MALA, 2002), the existing Spatial Development Framework shows areas of ecologically-acceptable expansion with regard to certain land use types, and areas where conservation of existing habitats are of essence (*Figure 4*). The Spatial Development Framework also clearly shows the areas where no development should be allowed at all, because of the ecological sensitivity. In the time since acceptance (2002), the Spatial Development Framework also guided several strategic planning issues such as the identification of a new waste site, a cemetery, new roads, and potential residential expansion zones. These efforts placed the city of Potchefstroom on the forefront of urban nature conservation in the North West Province.

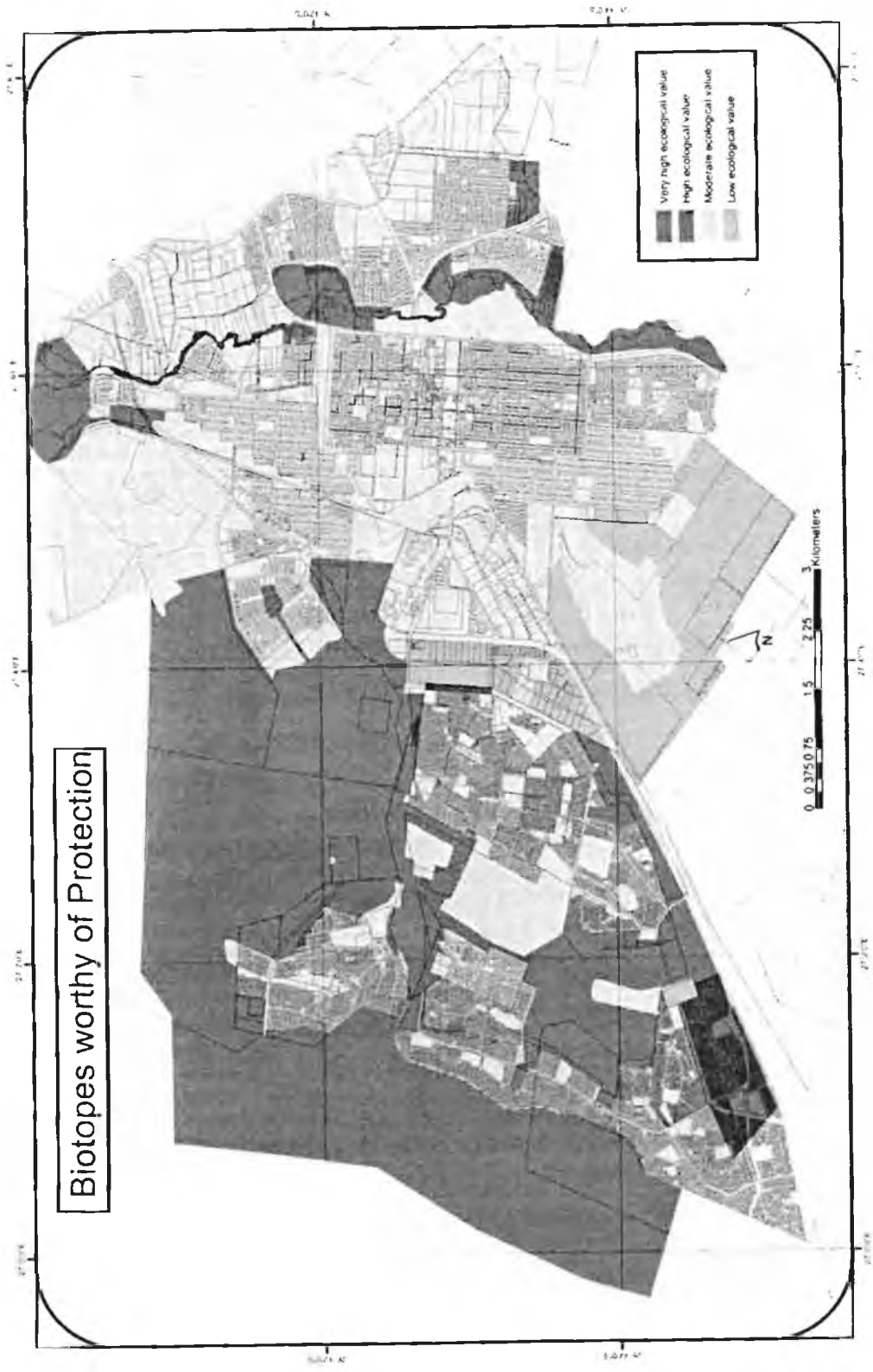

Figure 2: Biotope worthy of protection (Drewes & Cilliers, 2002)

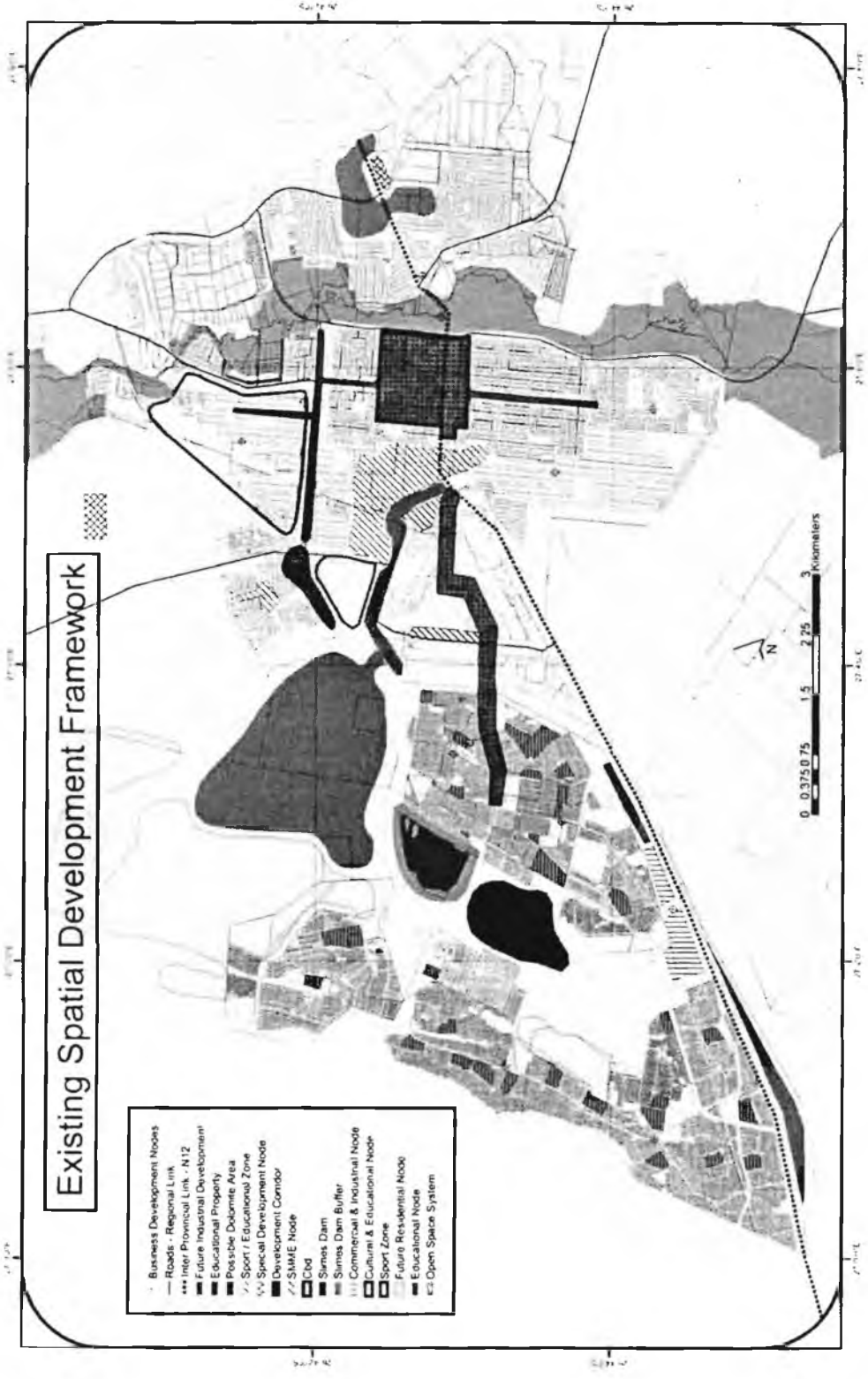

Figure 3: Existing Development Framework for Potchefstroom (Maxim Planning Solutions, 2002)

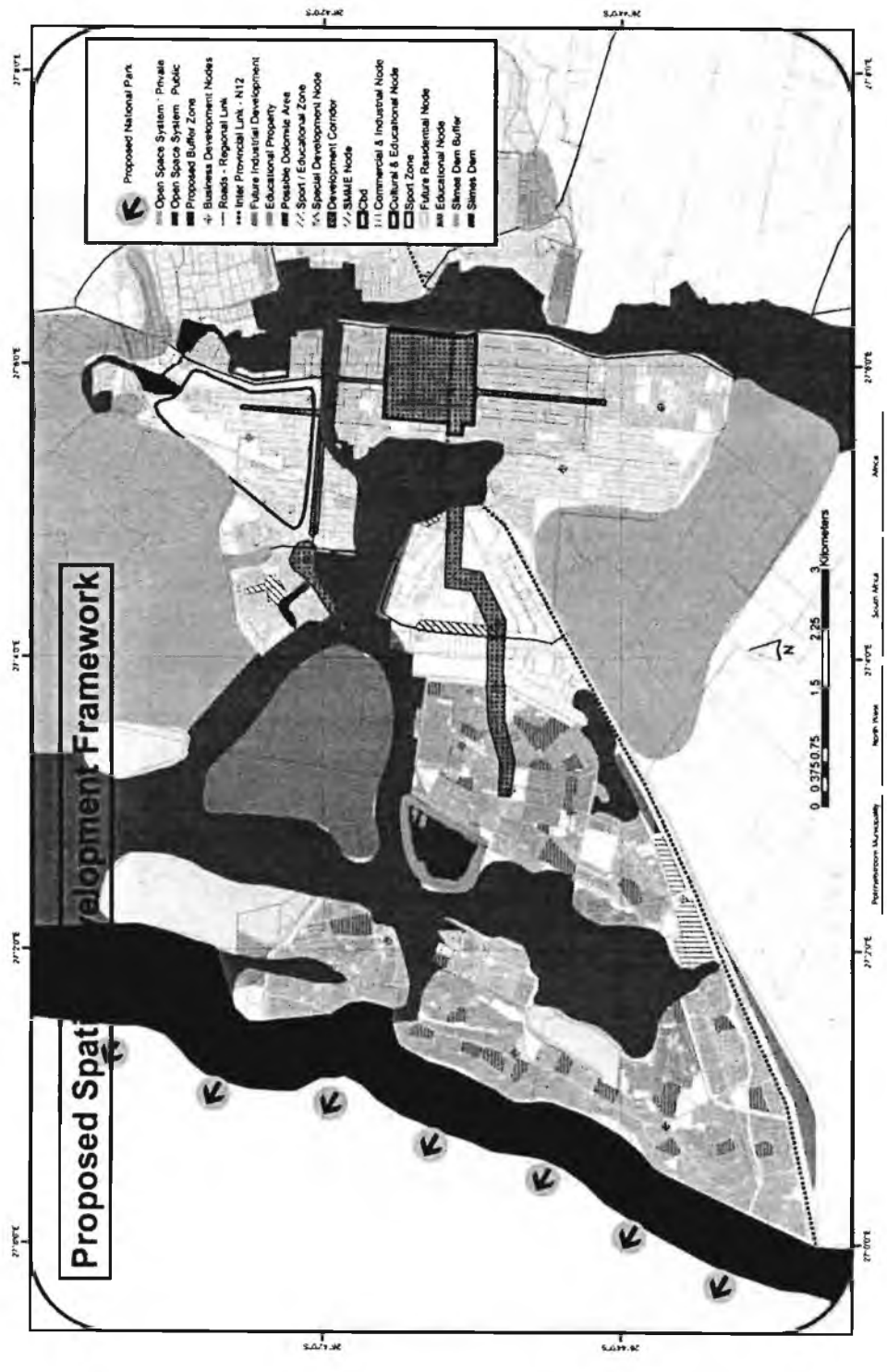

Figure 4: Proposed Spatial Development Framework for Potchefstroom (Drewes & Cilliers, 2002)

6. CONCLUSION

In conclusion, although sound policy and legislation is in place for spatial planning and environmental issues at a strategic level, it has been shown that these principles are not integrated in terms of its temporal, spatial and strategic applications (see Section 2). These guiding principles are described in an abstract manner, open to numerous interpretations at different levels of governance. It has also been argued in Section 2 that the necessary capacity does not exist at all government levels to implement and monitor these crucial processes, and that the application of policy and legislation also differs from municipality to municipality. Although a lack of detailed ecological and biogeographical data is a problem in the application of ecological-oriented planning and management of urban areas, the view of the public, the lack of infrastructure and financial limitations also burden this integrated process. The integrated process proposed and followed in the study area is an attempt to simplify a highly-complicated and cumbersome planning process on local municipal level. It is a relative affordable and realistic methodology aimed at the integration of spatial planning and environmental (natural) features of a study area, and is especially useful in secondary and smaller towns and cities where budgets for these exercises are extremely limited. It does not, however, seek to reduce the other critical components of the Integrated Development Plan. Spatial planning and environmental management are two main pillars of the Integrated Development Plan and this approach does not attempt to lessen the influence of all the other sectoral issues.

With regard to future research on this topic, it is deemed necessary to do follow-up studies and also extrapolate this information for application in other cities, towns and metropolitan areas. Refinement of evaluation criteria for areas worthy of protection is also needed, and refinement of the different types of planning categories. According to Löfvenhaft *et al.* (2002:223-240) it is important to distinguish between core areas, connectivity zones, buffer zones and green development areas, as each exercise different demands for spatial planning and management.

It must also be emphasized that future studies should incorporate human sociological aspects, as was clearly indicated by Gilbert (1989:1-7). According to Pickett *et al.* (1997a:185-199) humans should be seen as important ecological agents whose influences are included and studied within the conceptual framework of ecology, and their powerful capacities for social and spatial organization and for individual and group learning should also be recognized. Urban ecological studies must, therefore, also deal with the establishment of healthy and pleasing environments for humans (Niemela, 1999:117-131) and an understanding of how urban ecosystems work, how they change and what limits their performances (Pickett *et al.*, 1997b:183) as a unique combination of stresses, disturbances, structures and functions occur in urban areas (McDonnell & Pickett, 1990:1232-1237).

The main objectives of studies integrating ecological and social aspects will be to establish the affect of environmental changes on human well-being on issues such as health, wealth, knowledge, status, territory and power of different communities. Also, to establish more specific management strategies by following an integrated approach in the use, planning and management of urban, sub-urban and peri-urban land by understanding the nature of improving the sustainability. This approach would also provide opportunities for community involvement in various aspects of nature conservation, restoration and agriculture in urbanised and settled areas.

The principle outcome in terms of urban and regional planning would be a totally integrated land use management system that would replace existing town-planning and related land use management schemes. This land use management system would not only guide decision-making, but also show areas suited for specific development, and exclude certain types/intensities of development. Such a system is especially of relevance against the background of the Land Use Management Bill (MALA, 2002) that will require all municipalities to review existing land use management schemes in the near future.

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