DEVELOPING A FRAMEWORK FOR AIR QUALITY MANAGEMENT PLANS FOR SOUTH AFRICAN DISTRICT MUNICIPALITIES

By

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ABSTRACT

The promulgation of the National Environmental Management: Air Quality Act (No. 39 of 2004) introduced a system of decentralised ambient air quality management (AQM) in South Africa, to be achieved through the implementation of Air Quality Management Plans (AQMPs) at municipal levels. The framing of AQMPs within the broader Integrated Development Plan system introduces a relationship between AQM and other environmental/non-environmental management systems, allowing for the incorporation of air quality concerns into many other spheres of local and provincial governance. This decentralised system has increased the degree to which local municipalities are able to investigate, manage, mitigate, and control atmospheric pollution, but a lack of resources and skills presents numerous challenges in terms of legislation, policy, and AQMP roll-out. As such, a need for an AQMP development framework specifically designed for district-level municipalities was identified, and is the main objective of this research. This was achieved by reviewing both national and international literature, where examples from the UK and three metropolitan municipalities in South Africa were used in the development process. The final framework essentially comprises three sections: a two-stage baseline assessment, and a management and mitigation framework with a transparent system of reviewing and reporting. In order to test the implementation of this framework, Stage 1 of the baseline assessment was undertaken at iLembe District Municipality, where various aspects that affect, or are affected by, ambient air quality were researched and discussed. These included regional topography and climate, population distribution and density, emission sources, scheduled processes (listed activities), transboundary pollution, and climate change. In line with the constraints faced by district municipalities, it was shown that the general lack of resources and skills in iLembe will negatively impact upon the continued progress of pollution control in iLembe. Thus the need for capacity-building initiatives was recognised as being of great importance to the success of AQM in the municipality. The testing of this framework was restricted in its application owing to time constraints; hence the applicability of the entire framework has not been established. However, it can be reasonably anticipated that the framework's comprehensive application will realise the achievement of ambient pollution concentration standards in each municipality in an effective, resource-efficient manner, ultimately attaining a constitutionally-acceptable atmospheric environment in South Africa.

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AEL	Atmospheric Emission Licence
APPA	Atmospheric Pollution Prevention Act (45 of 1965), South Africa
AQAP	Air Quality Action Plan
AQM	Air Quality Management
AQMA	Air Quality Management Area
AQMP	Air Quality Management Plan
AQMS	Air Quality Management System
DEAT	Department of Environmental Affairs and Tourism, South Africa
DEFRA	Department of the Environment, Forestry and Rural Affairs, United Kingdom
GIS	Geographic Information System
IDP	Integrated Development Plan
LAQM	Local Air Quality Management, United Kingdom
NEMA	National Environmental Management Act (107 of 1998), South Africa
NEM:AQA	National Environmental Management: Air Quality Act (39 of 2004), South Africa
SAAQIS	South African Air Quality Information System

CHAPTER 1
INTRODUCTION

1.1 Background

Observations of the adverse effects of poor air quality on human and environmental health, as succinctly illustrated by the London smog events of the 1950s, have led to the widespread adoption of air quality legislation and control measures by many countries around the world (Vandenberg, 2005). Generally, the introduction of air quality management programmes under the guidance of legislation has resulted in significant reductions in air pollutant emissions from a variety of sources, consequently reducing the associated health risks.

However, air pollution legislation has changed considerably since the first Acts of parliament were promulgated. The evolution of the United States of America's (USA) air quality laws, originating with the Air Pollution Control Act of 1955, can be seen to typify this change at an international level. Originally passed to provide institutional capacity for research into air pollution, the Air Pollution Control Act was supplanted by the Clean Air Act of 1963 – the first US legislation aimed at controlling air pollution and emissions to the atmosphere. A research programme into monitoring and control techniques was established through the Public Health Service, which was expanded through the passing of the Air Quality Act of 1967, where enforcement proceedings began to be initiated (US Environmental Protection Agency, 2006).

The enactment of the Clean Air Act in 1970 resulted in a major change in the government's role in terms of air pollution control, where emission limits from stationary and mobile sources were first prescribed. One of the most important spin-offs of this act was the development of the National Ambient Air Quality Standards, which prescribed ambient atmospheric concentration limits for various pollutants. The 1977 amendments to the Act introduced management and control provisions for the prevention of air quality deterioration in areas not meeting the national standards, and this resulted in the increased standards and permit requirements for emitters. The Clean Air Act Amendments of 1990 were the most recent major changes to the legislation, where the authority and responsibility of national (Federal) government were greatly increased. More stringent standards for toxic air pollutants were also introduced, and enforcement authority was expanded and changed (US Environmental Protection Agency, 2006).

The evolution of South African air quality legislation has been similar to that described above, but prior to the year 2000, had received much less attention than the US Clean Air Act. In 1965 South Africa passed the Atmospheric Pollution Prevention Act (45 of 1965), or APPA, which although amended in 1973, 1981, 1985, 1989, 1996, and 1997, ultimately functioned as a regulator of pollution emitters and not ambient air quality (Davies, 2004). In contrast, the National Environmental Management: Air Quality Act (39 of 2004) (NEM:AQA) prescribes standards and related air quality management techniques for the regulation of *ambient* air quality, as is the case with the Clean Air Act. According to the NEM:AQA, *ambient air* refers to all air not regulated by the South African Occupational Health and Safety Act (85 of 1993) (Republic of South Africa, 2004, Section 1).

One of the principle tools for ambient air quality management introduced by the NEM:AQA is the compulsory implementation of air quality management plans (AQMPs) by all South African local municipalities, under the auspices of the provincial and national departments of environment. Although this is discussed in greater detail in Chapters 2 and 3, it is important to observe here that this shifts the focus of air pollution control. Where previously governed on a source-by-source basis, focus is now on managing an average environmental, or ambient, concentration for a range of pollutants which affect human health. The responsibility for the management of air quality has simultaneously shifted from centralised governance to the local authority, which further increases the scope for comprehensive and well-managed air pollution control.

There are three main spheres to the South African government system: the national legislature, which establishes laws and other policies and strategies which apply to the country as a whole; provincial legislature, which administers national policy at a regional scale; and district municipalities, which aim to provide democratic and accountable government, ensure the provision of services, promote social and economic development, promote a safe and healthy environment, and encourage participative governance (Republic of South Africa, 1996, Sections 83 – 164). The Local Government: Municipal Structures Act (No. 117 of 1998) further describes three categories of municipality: category A, or metropolitan municipalities; category B, or local municipalities; and category C, or district municipalities (Republic of South Africa, 1998a, Sections 2 – 10). A metropolitan municipality differs from a district municipality in that it has exclusive executive and legislative authority in its area. A district municipality has municipal executive and legislative authority in an area which includes a number of local municipalities. This research, whilst drawing on examples from metropolitan municipalities, is primarily focused on district and local municipalities, as shall be demonstrated.

AQMPs were already being developed for a number of metropolitan municipalities prior to the promulgation of the NEM:AQA, three of which will be scrutinised in Chapter 3. However, where metropolitan municipalities generally have greater capacity to implement and manage regulatory programmes and initiatives by virtue of their urban-related characteristics (such as a greater concentration of qualified people in the population and higher municipal budgets), district municipalities are disadvantaged by their contrasting attributes (i.e. few qualified people and low municipal budgets). This results in a scarcity of both skills and finances when it comes to air quality and general environmental management, and thus their ability to follow rigid AQMP development and implementation guidelines becomes compromised. Given this scenario, a need for a simpler, yet equally effective, AQMP framework for these municipalities exists that allows for smaller budgets and human resource constraints and future development.

1.2 Aim and Objectives

The aim of this research is to produce and apply a generic framework for the development and implementation of AQMPs in South African district municipalities using the existing management plans of the City of Johannesburg Metropolitan Municipality, City of Tshwane Metropolitan Municipality, and eThekwini Metropolitan Municipality. Literature from these municipalities, South African legislation and policies, as well as the experiences of the United Kingdom, will act as both sources of information and bases of comparison. The NEM:AQA guides the process of understanding what an AQMP is, what it is required to achieve, and the responsibilities of government in this regard. By discussing and comparing the various sources mentioned above, it will be possible to determine the main components of a standard AQMP, and this will in turn be applied to a South African district municipality. Prior to discussing the specifications of an AQMP, the Air Quality Act will be explored in greater detail in the thesis.

The objectives of the research are:

- to develop a generic framework for AQMPs in South African district municipalities, based on existing AQMPs, the National Framework for Air Quality Management, the national norms and standards, and the NEM:AQA;
- to test the efficacy of this framework in iLembe District Municipality (iLembe) with the municipality; and
- to report on the result of the test, and to make recommendations.

1.3 Structure of the Dissertation

Chapter 1, as per the preceding sections, establishes the background to the study, and sets the aims and objectives for the research project. Chapter 2 undertakes a review of pertinent South African legislation and policy frameworks with a view to establishing the legal context under which AQMPs are implemented and operated. Chapter 3 follows with a review of national and international literature on AQMPs, where a review of the three afore-mentioned South African metropolitan municipalities is included. The various aspects of air quality management are discussed, after which a generic framework for AQMPs in district municipalities is produced.

Chapter 4 constitutes the practical aspect of the research project, where the physical and anthropogenic characteristics of iLembe are reviewed in their capacity to influence, or be influenced by, ambient air quality. The results of this exercise are discussed in Chapter 5. Chapter 6 concludes the dissertation, along with recommendations for noted areas requiring further study in terms of iLembe’s AQMP.

CHAPTER 2
LEGISLATIVE CONTEXT FOR AIR QUALITY MANAGEMENT PLANNING IN SOUTH AFRICA

2.1 Introduction

This chapter will undertake a review of the relevant South African air quality legislation and policies, and will elaborate on the prescribed requirements for AQMPs. This discussion draws on the National Environmental Management Act (NEMA), the NEM:AQA and the National Framework for Air Quality Management, the South African Constitution, the Occupational Health and Safety Act, and the Municipal Systems Act. The legislation and policies discussed in this chapter provide the legal background and requirements for an AQMP, and hence inform the development of the framework described in Chapter 3.

2.2 National Environmental Management Act (No. 107 of 1998)

It is stated in the Bill of Rights of South Africa's Constitution that everyone has the right to an environment that is not harmful to their health, as well as to an environment in which pollution and ecological degradation are prevented, and conservation and ecologically sustainable development promoted (Republic of South Africa, 1996, Section 24). As such, a priority exists for the State to manage and control natural resources and their exploitation, including those substances which may have potential negative impacts on both people and the environment. It is well documented that many substances emitted to the atmosphere have a range of negative health and environmental impacts (Fenger, 1999; Jacobson, 2002; McGranahan and Murray, 2003; Turco, 2002; World Health Organisation, 2007). Thus, given the legal provision for pollution control, it follows that mechanisms are required to be put in place for the specific management and control of atmospheric pollution.

One of NEMA's subsidiary acts is the NEM:AQA, which was promulgated with the specific purpose of managing and improving ambient air quality in line with the principles set out in NEMA. The following section observes the key points of the NEM:AQA as they relate to air quality management, with a specific focus on the Act's subsections that pertain to AQMPs.

2.3 National Environmental Management: Air Quality Act (No. 39 of 2004)

2.3.1 Background

The main objectives of the NEM:AQA are to protect and enhance South Africa's ambient air quality, prevent air pollution and related ecological degradation, and to secure ecologically sustainable development (Republic of South Africa, 2004; Section 2). Ambient air, according to Section 1 of the NEM:AQA, refers to all air not regulated by the Occupational Health and Safety Act (No. 85 of 1993) (Republic of South Africa, 2004); in other words, ambient air refers to all air outside of the workplace (Republic of South Africa, 1993).

The manner in which ambient air quality is managed by the NEM:AQA is through municipal, provincial and national AQMPs (Republic of South Africa, 2004, Section 15), and also through their incorporation into Integrated Development Plans (IDPs) as stipulated by the Municipal Systems Act (No. 32 of 2000). Section 26 of the Municipal Systems Act describes the core components of IDPs as follows:

> "S.26. An integrated development plan must reflect – …
>
> (d) the council's development strategies which must be aligned with any national or provincial or sectoral plans and planning requirements binding on the municipality in terms of legislation;
>
> (e) a spatial development framework which must include the provision of basic guidelines for a land use management system for the municipality; …
>
> (g) applicable disaster management plans"
>
> (Republic of South Africa, 2000)

The integrations of AQMPs into the IDP structure allows air quality management considerations to be incorporated into other aspects of governance already included therein, such as transportation and economic development. In other words, aspects of air quality management can be considered in town planning exercises, as town planning departments are required to report under the same IDPs as AQMPs.

2.3.2 Requirements for AQMPs according to the NEM:AQA

Section 15 of the NEM:AQA states that all national and provincial departments charged with the responsibility for preparing environmental implementation plans or environmental management plans in terms of Chapter 3 in NEMA must include an AQMP within those plans (Republic of South Africa, 2004). These departments are the Departments of Environmental Affairs and Tourism, Land Affairs, Agriculture, Housing, Trade and Industry, Water Affairs and Forestry, Transport, and Defence (Republic of South Africa, 1998b, Schedule 1), as well as the Departments of Minerals and Energy, Health, and Labour (Republic of South Africa, 2004, Schedule 2). Section 15 also states that each municipality must include an AQMP in its IDP, as determined by Chapter 5 of the Municipal Systems Act.

Section 16 of the NEM:AQA discusses the contents of AQMPs, where an AQMP must:

> S.16. "(a) within the domain of the relevant national department, province or municipality, seek –
>
> (i) to give effect, in respect of air quality, to Chapter 3 of the National Environmental Management Act to the extent that that Chapter is applicable to it;
>
> (ii) to improve air quality;
>
> (iii) to identify and reduce the negative impact on human health and the environment of poor air quality;
>
> (iv) to address the effects of emissions from the use of fossil fuels in residential applications;
>
> (v) to address the effects of emissions from industrial sources;
>
> (vi) to address the effects of emissions from any point or non-point source of air pollution other than those contemplated in subparagraph (iii) or (iv);
>
> (vii) to implement the Republic's obligations in respect of international agreements; and
>
> (viii) to give effect to best practice in air quality management;

(b) to describe how the relevant national department, province or municipality will give effect to its air quality management plan; and

(c) to comply with such other requirements as may be prescribed by the Minister."

(Republic of South Africa, 2004)

Thus, in summary, each local municipality must include in its IDP an AQMP, which in turn will be reflected in the district municipality, provincial, and national AQMPs. AQMPs are therefore also required to be reported on in relevant annual reports as dictated by Section 16(1)(b) of NEMA (Republic of South Africa, 2004, Section 17).

Sections 21 and 22 of the NEM:AQA discuss the listing of activities which generate atmospheric emissions that impact upon human health and the environment. These activities are regulated through the application, acquisition and retention of an Atmospheric Emission Licence (AEL). Any such activity or process operator is required to comply with the terms and conditions of their acquired AEL, and may additionally be required to prepare and submit air pollution prevention plans or atmospheric impact reports on a regular basis, as per Sections 29 and 30 of the NEM:AQA. AELs replace the out-dated registration certificates required by operators of scheduled processes (synonymous with 'listed activities') under the APPA, although revision of the listed activities is currently underway, and is likely to be completed prior to the repeal of the APPA in 2009 / 2010 (Republic of South Africa, 2007, Table 35; Republic of South Africa, 2007a, Section 5.4.3.4).

2.4 National Framework for Air Quality Management

A National Framework for air quality has been developed in order to guide the achievement of the various objectives and regulations set out in the NEM:AQA (Republic of South Africa, 2004, Section 7). This framework includes mechanisms, systems and procedures to attain compliance with ambient air quality standards, and to give effect to the Republic's obligations in terms of international agreements. It also includes national norms and standards for: the control of emissions from point and non-point sources; air quality monitoring; air quality management planning; air quality information management; and any other matter which the Minister of the

Department of Environmental Affairs and Tourism (DEAT) considers necessary for achieving the objectives of the NEM:AQA (Republic of South Africa, 2004, Section 7(1)).

In order to provide for public access to air quality information in line with the National Framework's objectives, a South African Air Quality Information System (SAAQIS) is also currently under development. According to the National Framework, the SAAQIS will provide all stakeholders with easy access to all relevant information about air quality in South Africa, as well as provide stakeholders with different online applications to support effective and efficient air quality management (DEAT, 2007a, Section 5.2.1).

It is proposed that multiple interfaces will be developed in order to suit the needs of different stakeholders. For example, a thematic view would allow user to view all information related to a certain type of emission accompanied by easy-to-use search functions, whereas a graphic interface would be based on a geographic information system (GIS), where the content of the SAAQIS can be displayed as a map, thus allowing users to access information geographically. Information applications would be software programmes designed to execute data extractions, visualisations and/or calculations based on the content of the SAAQIS, and these would be particularly useful for the generation of performance reports (DEAT, 2007a, Section 5.2.1).

It is also anticipated that all government bodies responsible for the preparation of AQMPs will need to submit their monitoring data as well as their AQMP reports to the SAAQIS in order to create a centralised database for the whole country. As such, and for the sake of expediency, efficiency and reliability, municipalities will be required to develop and / or implement digital software systems that are capable of performing these upload functions. However, as this system is currently under development and as such is subject to change, no further discussion is warranted beyond acknowledgement of the SAAQIS's pending implementation.

The National Framework also prescribes guidelines for the development and implementation of AQMPs at national, provincial and local levels of government, and these are discussed in greater detail in Chapter 3 (Republic of South Africa, 2007a, Section 5.4.6). However, in the absence of a generic framework specifically for municipal AQMPs, a number of municipalities have already implemented various interpretations of this tool (Scorgie *et al*, 2003a; City of Tshwane, undated; eThekwini Health and Norwegian Institute for Air Research, 2007). Where the National Framework specifies a need for AQMP implementation prioritisation according to air pollution potential and affected communities / environments, such a necessity is translated in this research to include the need for a generic AQMP framework for district municipalities, as per the reasons discussed in Chapter 1.

The National Framework identified those municipalities experiencing or likely to be experiencing poor ambient air quality (DEAT, 2007a, Table 24). iLembe has been categorised as exhibiting 'potentially poor' ambient air quality owing to urban and agricultural activities, hence its selection for this research. The implications of this are discussed further in Chapters 3 and 4.

2.5 Additional Features of South African Air Quality Management

Over and above the obligatory implementation of AQMPs, it is also possible for municipalities to have pollution 'hot spots' declared as priority areas. Priority areas are defined as geographic regions in which the ambient air quality standards are being, or may be, exceeded, or where a situation that causes significant negative air quality impacts exists (Republic of South Africa, 2004, Section 18). A priority area AQMP must, through a process of stakeholder consultation, be developed with the aim of actively mitigating the identified negative air quality impacts as efficiently as possible through a system of localised co-ordinated air quality management (Republic of South Africa, 2004, Section 19). Such negative impacts will be identified by measured comparison with the ambient concentrations of specific pollutants as listed by the Minister. Table 2.1 indicates these ambient air quality standards as they were published on 2 June 2006. Note that provinces and local municipalities have the ability to apply for the introduction of more stringent location-specific ambient standards should they wish to do (Republic of South Africa, 2004, Sections 10 and 11).

It should be noted that any activity resulting in the emission of a substance published as a 'listed' pollutant is required to operate under permit conditions as set out by an approved AEL (Republic of South Africa, 2004, Section 21). Metropolitan and district municipalities are charged under the Act with implementing the licensing system, as per Section 36.

Table 2.1: Ambient Air Quality Standards for Common Air Pollutants (adapted from DEAT, 2006)

Substance	10-minute maximum	1-hour maximum	8-hour maximum	24-hour maximum	Annual average
Sulphur Dioxide (SO_2)	500 µg/m^3	350 µg/m^3		125 µg/m^3	50 µg/m^3
Nitrogen Dioxide (NO_2)		200 µg/m^3			40 µg/m^3
Carbon Monoxide (CO)		30 mg/m^3	10 mg/m^3		
Particulate Matter (PM10)				75 µg/m^3	40 µg/m^3
Ozone (O_3)		200 µg/m^3	120 µg/m^3		
Lead (Pb)					0.5 µg/m^3
Benzene (C_6H_6)					5 µg/m^3

The Minister is also empowered to require those activities operating under AELs to prepare and submit pollution prevention plans (Republic of South Africa, 2004, Section 29). Similarly, should an air pollution control officer suspect an activity or person of contravention of legal standards or permit guidelines, he or she may require that person or activity to submit an atmospheric impact report (Republic of South Africa, 2004, Section 30). Thus pollution prevention plans and atmospheric impact reports are potential control tools that may be included in a municipality's AQMP, particularly for those areas operating under a priority area AQMP.

2.6 Role and Responsibilities of Municipalities with regard to AQMPs

It has been recognised that adherence to or enforcement of national policies are not necessarily uniform in all areas of a country, and as such the potential for 'hotspots' arises. As a result, a national government is able to allocate the primary task of managing local air quality through appropriately assigned powers of governance (Elsom, 1999), as is the case in South Africa (Republic of South Africa, 1998b). The South African Constitution provides for decentralised governance in the delegation of duties to local and district municipalities (Republic of South Africa, 1996, Chapter 7).

As such, the ground work for implementing, enforcing, monitoring and managing air quality regulations is the responsibility of the respective municipalities. Sivertsen (2007) lists proposed municipal AQMP responsibilities as including: air quality and meteorological monitoring; emission monitoring and source identification; identification of priority pollutants; establishment of local emission standards; appointing an air quality officer; developing an air quality plan; performing emission licensing and authority functions; and collaborating with national and provincial authorities on priority areas.

However, according to Naiker (2007), a large proportion of South African municipalities face financial and human resources constraints, making the successful and effective roll-out of AQMPs relatively difficult. The challenges that government faces in this regard include widespread lack of experience, a lack of departmental capacity at all levels of government (i.e. local, provincial, and national), the need to standardise AQMP format in terms of its implementation and document layout, and quality assurance (DEAT, 2006). This research will remedy the need to standardise AQMP format for district municipalities, and will seek to address the other challenges through recommended AQMP components and procedures.

2.7 Concluding Remarks

Having discussed the legislative requirements for AQMPs in South Africa, the following chapter will provide an overview of air quality management planning as it is undertaken in the United Kingdom, where air quality action plans have been in use for approximately a decade, as well existing AQMPs in South Africa, and research currently taking place in South Africa with a view to exploring the requirements and contents of AQMPs in greater detail.

CHAPTER 3
TOWARDS A GENERIC FRAMEWORK FOR AIR QUALITY MANAGEMENT PLANS

3.1 Introduction

The key objective of this chapter is to produce a generic framework for an AQMP. Mindful of the legislative context of Chapter 2, this chapter begins by undertaking an analysis of United Kingdom (UK) legislation and associated air quality management requirements, given the similarities between the British and South African systems. Where the South African system of air quality management is tiered and progressively devolved at national, provincial and local levels, the British system is similarly devolved from the European Union 96/26EC Directive (acting as a 'national' or regional framework for ambient air quality management), the National Air Quality Strategy in the UK, and local authority AQM (Beattie *et al.*, 2001). Termed 'air quality action plans' (AQAPs), the British system differs from the South African system mainly in that AQAPs are only required should ambient air quality standards be exceeded, or expect to be exceeded. In this way, they can be considered similar to the priority area AQMPs in South Africa (Section 2.5). A discussion of AQAP methodology, as well as the reported strengths and weaknesses of AQAPs is undertaken in greater detail in Section 3.2.

Thereafter, the existing AQMPs for the Cities of Johannesburg, Tshwane and eThekwini are examined in greater detail, including a discussion on the shared components between the AQMPs of these three metropolitan municipalities. These three municipalities were selected as all are examples of industrialised municipalities with very detailed AQMPs. A comparison is then drawn between the British and three South African systems in pursuit of an optimal framework for South African municipalities.

3.2 Air Quality Action Plans – United Kingdom

In 1995, the British government promulgated the Environment Act (HM Government, 1995) in accordance with the European Union's (EU) Ambient Air Quality Assessment and Management Directive 96/26/EC, also known as the Ambient Air

Quality Framework Directive (Beattie *et al.*, 2001). The EU Directive prescribed limit values for certain pollutants, which all member states must meet by predetermined target dates. Thus the British air quality management system has a key role to play in achieving these targets (DEFRA, 2003). Under this new legislation, a national framework known as the National Air Quality Strategy (NAQS) was implemented in order to guide the development of policies with respect to the assessment and management of air quality, the focus of which was the establishment of health-based standards for 8 specific pollutants (DEFRA, 2003.). The Act also required the British local authorities to undertake a phased review of air quality in relation to the specific pollutant objectives. Should the results of these reviews indicate exceedances or likely exceedances, then those areas were to be designated as 'air quality management areas', subsequently resulting in the application of AQAPs for remedial management and control.

In order to understand the methodology behind AQAPs, it is important to examine the criteria governing their implementation, as well as their prescribed format as determined by government policy. The following section describes the methodology of the review process as dictated by state-issued documentation. This process, known as local air quality management, or LAQM, is guided by these documents as well as the Environment Act, although the process differs between individual local authorities based on emission sources, types of pollutants, and the scale of the problem, as well as individual stakeholder needs.

3.2.1 Methodology

There are essentially three broad stages to LAQM in the UK. The initial stage is a review of air quality in the local authority's area, both with respect to current pollutant concentrations, as well as forecast emission levels. This stage is known as the *review and assessment* phase. Should the outcome of this phase show that ambient concentrations of pollutants are higher than or likely to exceed prescribed standards in the future, the local authority is required to progress to a second stage, which is the *designation of an air quality management area* (AQMA). This is followed by the third phase involving the development and implementation of an AQAP (Beattie *et al.*, 2001; Beattie *et al.*, 2002a; Beattie *et al.*, 2002b; Elsom, 1999). A useful diagram summarising this AQM process, is provided by Beattie and Longhurst (2000) as shown with some minor modifications in Figure 3.1.

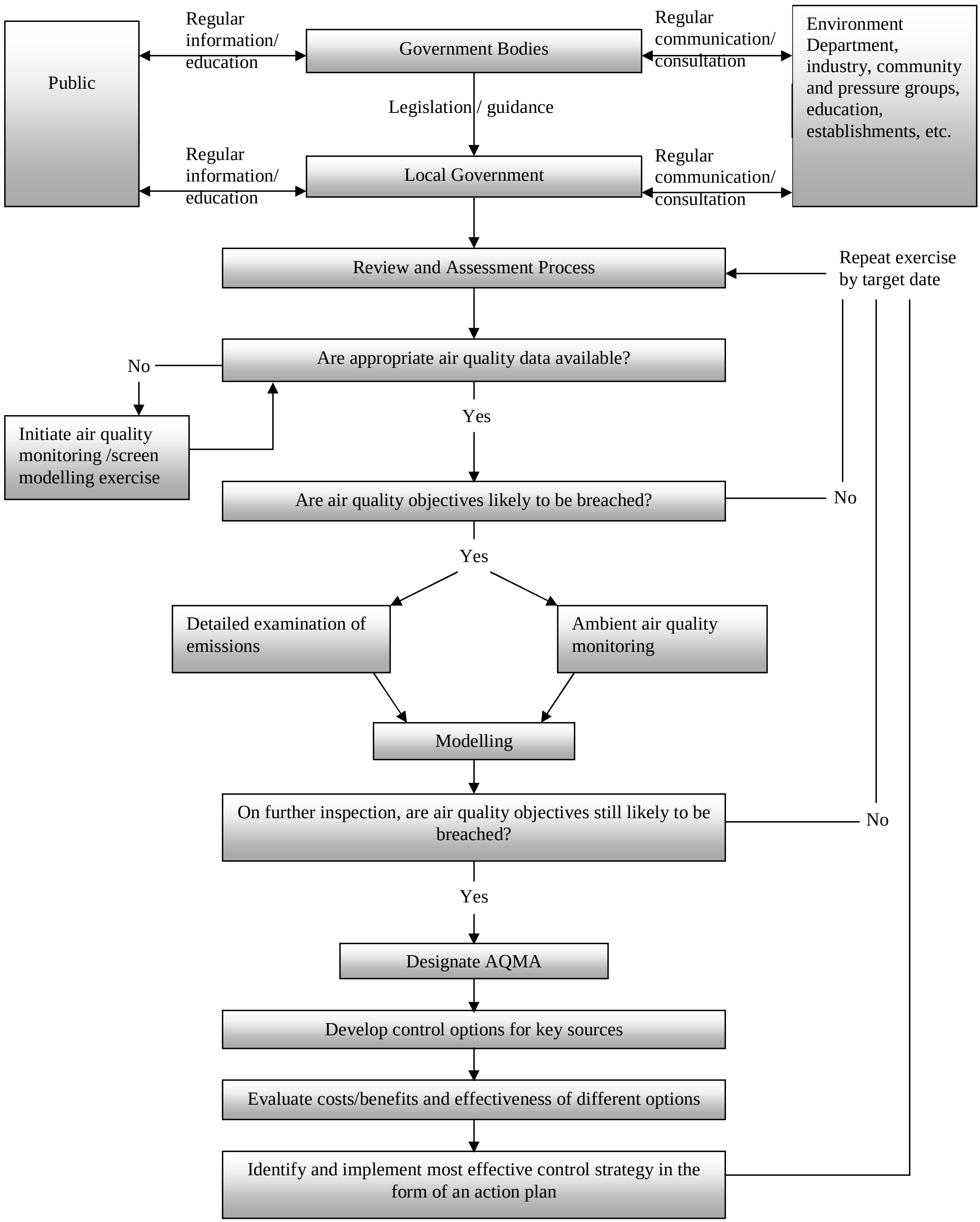

Figure 3.1: The UK AQM process (adapted from Beattie and Longhurst, 2000)

A policy guidance document issued by the Department for Environment, Food and Rural Affairs (DEFRA) was aimed at assisting local authorities in undertaking statutory air quality assessments by setting out the legislative framework for the system of LAQM (DEFRA, 2003). The three phases of LAQM (i.e. review and assessment, AQMA designation, and AQAP development and application) are described in this document, along with pollutant concentration objectives, target achievement dates, and various other related information. The following subsections summarise each of these phases in greater detail.

3.2.1.1 Review and Assessment Phase

The LAQM policy guidance document distributed by DEFRA defines a review of air quality as a consideration of the levels of pollutants in the air for which objectives have been prescribed, as well as the prediction of likely future levels of these pollutants (DEFRA, 2003:1-11). An assessment of air quality, however, is described as the consideration of whether estimated levels for the relevant future period will exceed the levels set out in the legislated objectives (DEFRA, 2003:1-11). Therefore, the review and assessment phase of LAQM requires local authorities to consider present and likely future air quality, and assess whether the objectives are likely to be achieved by the prescribed target dates. At the time of publication of the most recent policy guidance document, all local authorities in the UK had already completed the first stage of the review and assessment process (DEFRA, 2003:1-12); as such, a previous version of this document was consulted in order to establish the content of and requirements for the different review and assessment stages.

The Department of the Environment, Transport and the Regions (DETR) published a series of four policy guidance documents and four technical guidance documents in order to assist local authorities with the LAQM process (referred to as DETR, 2000a-d). The first document states that a review and assessment of local ambient air quality is the first and most important step in the LAQM process (DETR, 2000a:6). The most significant judgement that local authorities are required to make during this process is whether or not the air quality objectives are likely to be achieved in their area by the relevant date, as if they are unlikely to be achieved, then an AQMA must be declared, followed by the implementation of an AQAP (DETR, 2000a:8).

According to the policy guidance, the complexity of a review and assessment should be consistent with the risk of failing to achieve air quality objectives by the specified date. As such, the guidance recommends a phased approach involving 3 stages of increasing scope, where stages 1 and 2 should generally be precautionary, and stage 3 should provide detailed assessment information (DETR, 2000a:10). Table 3.1 summarises these stages. The system is based on a precautionary approach, such that any geographic areas that may present doubt regarding pollution concentrations should rather be assessed further than ignored (DETR, 2000a:14).

Table 3.1: The LAQM Review and Assessment Process (summarised from DETR, 2000a:12-19)

Stage	Description	Required Information
One	Information on any significant existing or proposed source of pollutants of concern within a local authority must be acquired. Human exposure over prescribed averaging periods must be considered. Significant sources of pollution beyond the local authority's area should also be considered in terms of transboundary pollution. A 'significant' source is one which causes a significant risk, either singly or in combination with other local sources (DETR, 2000a:12). Should any areas be determined likely to exceed air quality objectives after the first review and assessment stage, then the local authority should proceed to the second stage.	• Details of any significant transport-related sources of pollution. • Details of industrial sources of pollution, including name, address, location, applicable legislative control, and an emissions inventory. • Details of significant external (i.e. outside local authority) sources of pollution. • Details of other existing or proposed significant pollution sources. • A description of the information sources of a pollutant. • Details of any surveys or investigations carried out to compile the report. • Other information required includes an area map, a list of activities and processes that may cause significant pollution, and a list of pollutants with their corresponding locations (if any) that may need further examination.
Two	The aim of the second stage is to screen pollutant concentrations still further. It is not meant to predict levels of current or future air quality with absolute accuracy across the whole of the authority's area, but should focus on areas identified by the first stage as being significant. The authority should estimate ground level concentrations of the relevant pollutants for these areas at a combination of roadside and/or industrial and/or urban background locations, as appropriate. From these estimates, authorities can predict each pollutant's potential concentrations at the end of the relevant period. (DETR, 2000a:14).	The second-stage report should begin by listing the pollutants requiring further examination, including the following for each pollutant: • Details of any automatic or non-automatic monitoring, including species, concentrations, averaging times, monitoring period, accuracy, monitoring techniques, details of the sampling system, site details, the basis for site selection, quality control procedures, calibration gas traceability where appropriate, description of data processing techniques, information on data return, and reference to technical guidance; • Details of any modelling, including model outputs showing pollutant concentrations, details of input data, the name and description of models used, information on estimated uncertainty in outputs, details of model validation, and reference to technical guidance. • The report should also include a map, as well as a list of pollutants requiring further assessment.

Three	The third-stage should be undertaken when the first and/or second stage have revealed a significant risk of an air quality objective not being met for any pollutant of concern. In the third stage, the authority is expected to carry out an accurate and detailed review and assessment of current and future air quality, and as such, monitoring and modelling processes are mandatory. However, it is only at this stage that authorities are likely to need sophisticated modelling and monitoring techniques, and will vary according to the extent of current techniques in use. Local authorities must predict whether they are unlikely to achieve an air quality objective on time at a relevant location, as this will be the crucial factor triggering the designation of an AQMA. Authorities should not declare AQMAs unless the third stage of the review and assessment has indicated that air quality objectives are unlikely to be met on time. In other words, an AQMA cannot be declared based on the outcome of a first- or second-stage review and assessment.	The report for the third-stage review and assessment should begin by listing the pollutants that need further examination, based on the first/second stage. For each pollutant, information regarding the following should be included: • Details of any automatic or non-automatic monitoring, including species, concentrations, averaging times, monitoring period, accuracy, monitoring techniques, details of the sampling system, site details, the basis for site selection, quality control procedures, calibration gas traceability where appropriate, description of data processing techniques, information on data return, and reference to technical guidance; • Details of the construction of any emissions inventories, including the pollutants considered, the relevant period, the spatial resolution, geographical boundaries, information sources used to find the factors influencing current and future emission levels, and a methodological statement referring to the technical guidance on emission inventories; • Details of any modelling, including model outputs showing pollutant concentrations, details of input data, the name and description of models used, information on estimated uncertainty in outputs, details of model validation, and reference to technical guidance; and • Details of the review and assessment methodology, including references to technical guidance or other published material, estimated background concentrations used in the assessment, and full details of how many surrogate statistics for estimating averaging time for a pollutant concentration have been worked out, if relevant. • A map should also be included with the report. • The third stage report should also include a summary of the findings for all regulated pollutants, and this should make it clear why the authority made any relevant decisions. The report should conclude by listing all pollutants for which it considers it will not meet the objectives in time, including locations, as these will then be used for the designation of an AQMA.

It is possible to summarise the information provided in Table 3.1 diagrammatically, as presented in Figure 3.2.

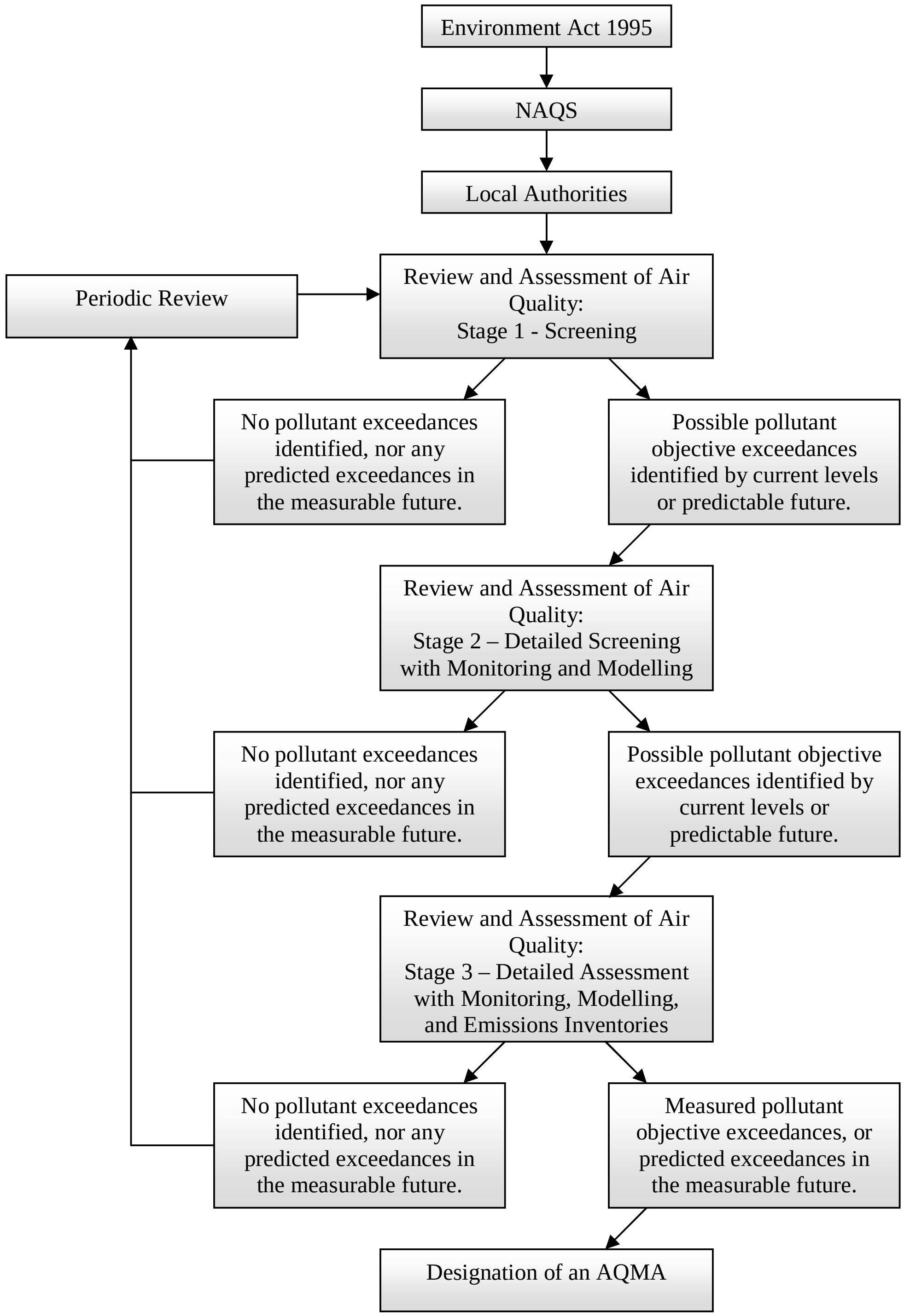

Figure 3.2: Diagrammatic representation of the Review and Assessment Process (adapted from DETR, 2000a:12-19).

3.2.1.2 Air Quality Management Areas

As indicated in Table 3.1 and Figures 3.1 and 3.2, a local authority is required to declare any location in which ambient pollutant objectives have been or are likely to be exceeded as an AQMA. Notably, this only applies to areas in which significant public exposure to air pollutants is likely to occur (DEFRA, 2003:1-18). This process does not relate to standard AQMPs in South Africa, given their mandatory implementation by all municipalities; however, understanding boundary delineation may assist in the allocation and demarcation of priority area AQMPs.

The guidance documentation does not dictate a methodology for delineating the geographical extent of an AQMA, only stating that such boundaries are at the discretion of the managing local authority (DEFRA, 2003:2-1). Assistance for boundary delineation is given in the form of a list of considerations, including natural and built-environment topology, ease and practicality of management in relation to area, and the possibility of subdividing an AQMA into smaller areas in order to focus on managing individual areas as air quality improves over the larger area (DEFRA, 2003:2-1).

Once designated as an AQMA, a local authority is required to undertake a further assessment of air quality in the AQMA within 12 months of declaration, followed by a report. This information is then used to monitor air quality in the AQMA on an ongoing basis, and also contributes usable data for the AQAP.

3.2.1.3 Air Quality Action Plans

An AQAP is a management structure implemented by a local authority in an AQMA for the improvement of ambient air quality, where a review and assessment of air quality has shown that national measures are insufficient for meeting ambient air quality objectives (DEFRA, 2003:3-1). Such a plan must include:

- the quantification of the source contributions to the predicted exceedances of the air quality objectives, allowing the plan measures to be effectively targeted;
- evidence that all available options have been considered on the grounds of cost-effectiveness and feasibility;

- a strategy for the implementation of the action plan, including partnerships with other organisations, in pursuit of the air quality objectives;
- clear timescales in which the authority and other organisations and agencies propose to implement the measures within its plan;
- quantification of the expected impacts of the proposed measures and, where possible, an indication as to whether the measures will be sufficient to meet the air quality objectives; and
- a monitoring and evaluation strategy for the plan's effectiveness.

As the previous phase, namely AQMA designation, required detailed assessment of pollution sources, a variety of baseline data will already exist which will assist in identifying pollution sources, such as road transport and industry. In terms of AQAP effectiveness, the DEFRA guidance documentation suggests that local authorities should aim to include a cost-effective analysis of each individual pollution control measure proposed, particularly with respect to economic, environmental and social concerns (page 3-2).

DEFRA also strongly suggests collaborative development and management with other local authority departments such as environmental protection, transport, planning, economic development, and land use planning, as well as affected industries in the AQMA. This is to ensure a multi-disciplinary approach that has the potential to produce the most effective and efficient action plan possible for a particular AQMA. It is suggested that a steering group be formed in order to lead the development and implementation of a local authority's AQAP. The steering group should include members of other local authority air quality steering groups for the purpose of shared-experience learning (DEFRA, 2003). In view of this, it should be noted that collaboration between neighbouring local authorities has resulted in approved regional AQAPs with the particular aim of regulating the joint impact of localised AQAPs (DEFRA, 2003:3-4).

DEFRA describes the key aspects of an AQAP as follows. It should begin with an introductory chapter which refers to the statutory obligations of the local authority as described by the relevant act (in the UK, this is the 1995 Environment Act). This is to be followed by a list of the measures that have been considered to tackle poor air quality, and the identification of those to be implemented following a basic cost-effective analysis of the different measures. These measures should indicate, where possible, what the anticipated air quality improvements are likely to be. Each of the measures should set out, where possible, what the broader improvements or impacts might be following their implementation.

Any AQAP should indicate expectations of the local authority, as well as all other agencies involved with the action plan, such as those mentioned previously (environmental protection, transport, planning, economic development, land use planning, etc.). Where actions fall beyond the remit of the local authority, the plan should indicate a methodology for addressing these actions. Finally, a timetable showing target implementation dates should be included, addressing in particular, the implementation of control measures (DEFRA, 2003:3-5).

In order to ensure that implementation deadlines are adhered to, local authorities are required to submit annual progress reports to the relevant governing body. Such progress reports simply list the measures within the action plan and include the timescales by when they are/were due to be implemented, as well as provide updated information on implementation progress (DEFRA, 2003:3-8).

For the purpose of comparing pollution reduction priorities and strategies between the UK and South Africa, Table 3.2 shows summarised examples of local authority measures to improve air quality. Prior to concluding this section, it should be noted that statutory provision is made for the role of consultation and liaison between local authorities and other agencies, businesses, the local community and other local authorities to improve local ambient air quality. This includes consultation on a local authority's air quality review and assessment, further air quality assessments in an AQMA, and the preparation or revision of an AQAP (DEFRA, 2003:4-1). This is discussed extensively in the DEFRA guidance document on policies, but falls beyond the scope of this research.

Table 3.2: Examples of local authority measures to improve air quality (DEFRA, 2003:3-9 – 3-11).

Local Authority Pollution Control Measure	Application Sector	Description
Local air pollution control	Industry	Regulation of industrial emissions. This regime covers emissions to the atmosphere and covers approximately 17,000 individual processes. Local authorities may grant 'authorisation' for a process to operate subject to certain conditions, where operators must use the best available techniques not entailing excessive cost (BATNEEC) to ensure pollution is minimised (i.e. it is a permitting system). Breach of such conditions is an offence served by legislation. The significant advantage of the adoption of this regime is that is allows local authorities and operators to work together over the long term to reduce atmospheric pollution to a minimum.
Industrial smoke control	Industry	This allows the control of emissions from those processes operating outside of the permitting system (above), and includes powers to prohibit dark smoke from a chimney, building or premises, require notification of the installation of industrial furnaces, and approve chimney heights of certain furnaces.
Domestic smoke control	Public	This measure helps to reduce and regulate smoke and ground level sulphur dioxide from domestic sources. Its effect is to require people to adapt their fireplaces to burn smokeless fuel, restrict the burning of unauthorised fuels, and restrict the sale of unauthorised fuels. In a smoke-control area, it is an offence to emit smoke from any chimney.
Statutory nuisance	All	Should a local authority deem that a nuisance exists or is likely to recur, it may serve an abatement notice. Subject to certain exemptions, such a nuisance can include smoke and dust emitted from a premises, fumes or gases emitted from private dwellings, and dust, steam, smells or other effluvia arising on industrial, trade or business premises. Local authorities use this regime to deal with emissions that, by definition, are prejudicial to health or constitute a nuisance, but it is not a standards-based approach.

3.3 Air Quality Management Plans – South Africa

As previously mentioned, a number of municipalities in South Africa have already developed and implemented their own AQMPs prior to the publication of the national guidelines. Although the national guidance documentation once available should be considered as the primary source of information for the development of AQMPs, in the absence of guidelines, there is an opportunity to explore possible frameworks and to aim to make the findings of this study known to the team developing the guidelines. As a precursor, the benefits and shortcomings of some of the existing AQMPs in South Africa are examined and discussed.

The following sections present a summary of the three AQMPs for South African metropolitan municipalities introduced in Section 3.1, namely Johannesburg, Tshwane and eThekwini, and discuss the similarities and differences evident in their implementation and management strategies. This is followed by a comparative analysis of AQM planning in South Africa and the UK (Section 3.4) and then a discussion on the national norms and standards for AQMPs as presented in the National Framework document (Section 3.6). The final sections of the chapter aim to provide an optimal framework for district municipality AQMP development in South Africa.

3.3.1 City of Johannesburg AQMP

The City of Johannesburg (Johannesburg Metropolitan Municipality) outsourced the development of its draft AQMP to an independent team of environmental consultants, namely Matrix Environmental Consultants (Scorgie *et al.*,2003a). It should be noted that this plan was drafted and completed prior to the promulgation of the NEM:AQA and as such there are a small number of statutory requirements prescribed by the legislation that may not have been accounted for in the Johannesburg AQMP. However, it is likely that these aspects will be incorporated into the AQMP as soon as it is revised.

The final Johannesburg AQMP report identified two main components, namely the situation assessment study, which comprised a baseline assessment of air pollution concentrations and air quality management practices in the city, and secondly, the AQMP development (Scorgie *et al.*, 2003a). It is pertinent to acknowledge two explicit objectives stated in the AQMP, as they are indicative of the adoption of the precautionary principle: firstly, that the principles of cleaner production will be promoted, which essentially involves reducing pollution emissions at source through improved technology and process engineering; and secondly, that energy efficiency will also be promoted, which will reduce energy consumption-related emissions through lessened demand on national resources, as well as on-site fuel use. A specific description of the management plan development process was made, the key considerations for which are summarised hereafter (Scorgie *et al.*, 2003a).

According to Scorgie *et al.* (2003a), there must be a focus on air quality management framework development in the short-term, particularly with a view to including the required organisational and functional structures of a comprehensive management framework. This should also include an integrated air quality management system comprising an emissions inventory, air quality and meteorological modelling, dispersion modelling and environmental reporting. Without such a system, there will be insufficient data for the development of management measures, and the implementation progress of such control measures will be unquantifiable.

Emphasis must be placed on the implementation of emission reduction measures for major pollution sources. It is imperative that emission reduction measures be carefully selected to ensure that the most significant sources in terms of potential for impacts on human health and wellbeing are targeted. The identification of sources for which the implementation of emission reduction measures are to be applied in the short-term must be justified. Any such evidence may comprise preliminary emission estimates, ambient air quality monitoring data, and health risk studies. Significantly, vehicle emissions were noted to be one of the most significant emerging air pollution issues on the basis of preliminary estimates, anticipated increases in traffic volume and congestion, elevated pollutant (NO_X, CO and O_3) concentrations, and the widespread identification of this sector as being of primary concern by many developing nations (Scorgie *et al.*, 2003a).

It is also important to identify sources for which further assessment is required in order to determine the need for and/or most suitable type of emission reduction measures. Such sources may include incinerators, landfills and waste water treatment works, although the Johannesburg study identified an information deficiency with respect to determining the impact of individual operations. Other sources which at that time were unquantifiable in terms of emissions or impacts included industrial and commercial fuel burning appliances, wild fires and fugitive releases from agricultural activities.

There is also an identified need to facilitate inter-departmental co-operation in the identification and implementation of emission reduction measures for certain sources. The implementation of emission reduction measures for certain sources required that the Johannesburg Departments of Environmental Management and Environmental

Health set up co-operative arrangements with other local departments, particularly with regard to the identified risk of increasing traffic-related emissions (where the Department of Transportation Planning was likely to be co-opted). Such co-operation, in the short-term, would need to focus on the establishment of inter-departmental co-operative structures, which in the medium- to long-term, would support the identification and implementation of effective emission controls.

According to Scorgie *et al.* (2003a:x - xxxvi), an AQMP should include a number of specific foci, originating in an AQM policy based on the Constitution, the Bill of Rights, national environmental policy, *viz.* NEMA, the Integrated Pollution and Waste Management (IP&WM) White Paper (Republic of South Africa, 2000b), and international trends in AQM policies. This should be followed by local AQM objectives, which in the case of Johannesburg's AQMP, established three thresholds for specific pollutant-averaging periods: limit values, information and investigation thresholds, and alert thresholds. These thresholds were accompanied by an action table which specified target implementation dates for the AQM objectives.

An AQM system, or AQMS, was recommended for development and inclusion to guide the implementation and revision of AQMPs. The essential tools of an AQMS are an emissions inventory, air quality and meteorological monitoring, and atmospheric dispersion modelling, which together form the basis of effective air pollution control and air quality management. The short-term components of Johannesburg's Basic AQMS are: local air quality guidelines, an emission inventory, an air quality and meteorological monitoring network, atmospheric dispersion modelling, routine reporting, and public liaison and consultation. Health risk assessments and damage assessments can be undertaken based on the output of the AQMS, specifically in-house (through models and locally-derived input data, as well as manual calculations) and externally (through the appointment of consultants).

Following this, emissions quantification and reduction measures are required, where an internationally-adopted protocol for developing an emissions reduction programme was recognised. This included: the identification of pollutants to be controlled; the identification of all sources of each pollutant, including quantity, percentage contribution, emission height, and likelihood of exposure; and the identification of air pollution reduction strategies.

Research initiatives are also suggested in order to ensure the ongoing effective implementation of the AQMP. Complementary to this is the drive for capacity-building, which would ensure efficient and cost-effective service delivery with respect to air quality management and planning. According to Scorgie *et al.* (2003a), this would typically include human resources, facilities, source and ambient monitoring equipment, emission calculation methodologies, hardware and software, etc.

Finally, an AQMP approval and review process is essential to continued improvement and enhancement of the AQMP, where a number of groups and structures are put in place to guide the AQMP development project team. Such groups in the Johannesburg project included a steering committee which comprised representatives from municipal, provincial and national environmental departments, technical advisory groups which review the technical merit and feasibility of the plan, and an air quality stakeholder group comprising all interested and affected parties such as business, industry, non-governmental organisations (NGOs), community-based organisations (CBOs) and labour. Although no provision is made in the NEM:AQA for regular reviewing of AQMPs, it is suggested by Scorgie *et al.* (2003a) that such reviews should be undertaken annually based on national regulations pertaining to compliance and emission standards, as well as any updated guidance documentation.

3.3.2 City of Tshwane AQMP

Whereas the Johannesburg AQMP acknowledged possible inclusion of AQM into its IDP, the Tshwane AQMP recognised the statutory link between the two (City of Tshwane, 2006:2) (this is likely attributed to the NEM:AQA having been passed once Tshwane began its AQMP development). Similar to Johannesburg, the Tshwane AQMP explicitly states the objectives of promoting cleaner production and energy efficiency (City of Tshwane, undated). It is also pertinent to note that the municipality's AQMP was developed in parallel with its Energy Strategy Report, which aimed to provide baseline data for a sustainable energy and climate change strategy to be rolled out in conjunction with the municipality's AQMP (City of Tshwane, 2006). This principle of joint development is explored further in Section 3.7.2, where the importance of inter-departmental co-operation is discussed in greater detail.

In terms of the plan's main objectives, the only significant difference between Tshwane's and Johannesburg's plans is that Tshwane has attempted to make provision for "an air quality management information system containing air quality data that are compatible with acceptable modelling requirements and management information system requirements" (City of Tshwane, undated:3). It is unclear whether this is in reference to an emission database, or a digital management system capable of incorporating modelling and other data. For the purposes of this research, it shall be assumed that both are inferred.

Aerial photographs of the municipality are included in the AQMP report, along with a description of the topographical features which may impact on pollution dispersion. Descriptions of population densities are evident, although no precise data are presented, just relative qualitative analogies. Beyond this, however, the report is similar in structure and content to the Johannesburg AQMP, containing an air quality management policy with objectives, the same thresholds utilised by Johannesburg (i.e. limit values, information and investigation thresholds, and alert thresholds), tabulated implementation actions, an AQMS, emission and source descriptions with recommended control measures, research initiatives, and a reviewing and reporting strategy (City of Tshwane, undated). It can thus be inferred that Tshwane has based their AQMP on the work by Scorgie *et al.* (2003a), with minor adjustments made to compensate for the promulgation of the NEM:AQA.

3.3.3 eThekwini Metropolitan Municipality AQMP

eThekwini Municipality's AQMP was jointly developed by the local Health Department and the Norwegian Institute for Air Research (NILU) and is currently available as a final draft (eThekwini Health and Norwegian Institute for Air Research, 2007). It is noted as an aside that NILU has concurrently been tasked with the development of the national AQMP norms and standards. The aims described in the eThekwini AQMP are effectively transcribed from the aims of an AQMP stipulated in Section 16(1)a of the NEM:AQA (Chapter 2, Section 2.3). Notable omissions are: giving effect to best practice in AQM, ensuring transparent and traceable processes in the AQMP, and ensuring the use of science, policy, multi-stakeholder involvement and enforcement for achieving a better quality of life (eThekwini Health and Norwegian Institute for Air Research, 2007:8).

A pertinent difference between eThekwini's AQMP and those of Johannesburg and Tshwane, is the acknowledgement that the South Durban Basin is a pollution hotspot, which effectively earmarks the area for declaration as a priority area. The MultiPoint Plan (MPP), implemented in 2000 in the South Durban Basin for the purpose of providing an improved and integrated decision-making framework for AQM at the local government level, resulted in the establishment of a comprehensive monitoring network with data available since December 2003 (eThekwini Health and Norwegian Institute for Air Research, 2007:8-10). Thus eThekwini is in a relatively unique position with respect to the initial stages of air quality assessment, as it is already in possession of data for a large proportion of its jurisdictional area. Concurrently, a number of emission inventories have been generated for the central business district (CBD) and the South Durban Basin (eThekwini Health and Norwegian Institute for Air Research, 2007:13), which together with a health study (page 19) provide further support to the efficient and timely implementation of the AQMP, once it is complete.

The draft AQMP describes three broad goals, specifically short-term goals describing the development of implementation plans and strategies, long-term goals which describe the development and implementation of air quality indicators and control measures that are possibly more stringent than those described in the legislation, and a final goal aimed at strengthening AQM through integration with other local government processes (such as area and transport planning) (eThekwini Health and Norwegian Institute for Air Research, 2007:21).

Over and above this, the overall strategy includes an integrated AQMS, stakeholder partnerships, an active information dissemination strategy through media such as the internet, mobile phone text messaging, email, reports, presentations, and news bulletins, a health-based approach to air quality management, and an implementation plan (subdivided into an air quality management strategy and an action plan) (eThekwini Health and Norwegian Institute for Air Research, 2007:23).

The AQM strategy for eThekwini's AQMP describes the steps to implementation as beginning with an initial assessment of current air pollution concentrations, which should be undertaken with respect to standards and guidelines, prescribed by legislation and other controls. Control options (or, according to the terminology in the Johannesburg and Tshwane AQMPs, measures) must then be developed based upon firm knowledge of the pollution sources, the technologies available for controlling the various pollutants, as well as the potential for improving, modifying or replacing these technologies.

An analysis of the effectiveness of the control measures in reducing pollution concentrations must also be undertaken, paying due attention to short-, medium- and long-term control strategies, which must then be selected and enforced. Attention must also be given to the public and all stakeholders, who must be informed about the air quality status and the strategies and plans for improving the air quality. This must be done through effective information dissemination techniques (eThekwini Health and Norwegian Institute for Air Research, 2007:26).

A useful diagram provided in the report describes the three main elements of AQM (Fig. 3.3). These elements form part of what has been termed the AQM framework, and this provides a summary of the processes occurring at each stage of implementation. The remainder of the document discusses various control measures currently in place, as well as proposed future strategies for the priority pollutants identified in the municipality. Such discussions include monitoring methods, dispersion and exposure modelling, air pollution damage assessment, an assessment of the current air pollution concentrations, and the licensing and auditing process (eThekwini Health and Norwegian Institute for Air Research, 2007).

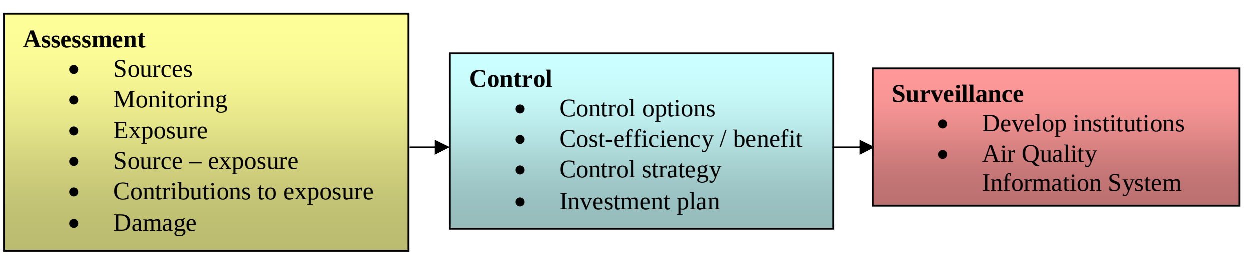

Figure 3.3: The three main elements of an air quality management framework (eThekwini Health and Norwegian Institute for Air Research, 2007:27-28).

3.4 Analysis of UK and South African Air Quality Management Planning

Longhurst *et al.* (1996) discussed the essential components of an AQMP prior to the implementation of the British system. In summary, this began with air quality goals and objectives to help avoid the development of conflicting policies. A range of emissions covered by national controls, as well as other pollutants considered important by other agencies (e.g. the public, international organisations etc.) were then considered, and acceptable monitoring programmes for the key pollutants identified were developed, cognizant of standards and guidelines appropriate to the relatively lengthy timescale over which the AQMP will be implemented. Dispersion modelling was undertaken in order to assess current and potential future air quality and to enable informed decision-making. Dissemination of all relevant information to the public, including methods of complaint, threshold breach alerts, and periodic reports ensured transparent stakeholder inclusion, and a set of procedures to deal with the occasional acute occurrence of very poor air quality, known as an air quality alert system, was introduced. The reconciliation of air quality goals with other government initiatives such as transport plans, highway policies, car parking policies, pedestrian policies, industrial development policies, etc. was realised through this system. As AQMPs in South Africa are linked to other local government departments and development plans through municipal IDPs, many of these latter specifications can be achieved through the adoption of effective co-operative governance.

Elsom (1999) discusses the development of the AQMS in the UK from the time of its development through to the early stages of the review and assessment process, where it was noted that one of the key successes of the implementation of this system was the development and availability of national resources upon which local authorities could draw. Such resources included: monitoring data through the development of the Automatic Urban Network – a government-funded system of automatic air quality analysers monitoring certain pollutants, and covering over one hundred sites in 1998; a National Atmospheric Emissions Inventory, with much of the information available on the internet, providing emission estimates for key pollutants at a 1 km^2 resolution; and simple and complex air quality dispersion models for all key pollutants, which are an essential feature of the second and third stages of the review and assessment process, as well as continued air quality monitoring.

South Africa intends to mimic aspects of this AQMS through the development and implementation of a national information system (SAAQIS), which will also be available online in various formats (Section 2.4). However, at present there are no known plans for national assistance with the funding of monitoring networks or modelling exercises beyond any relationships already in place with individual municipalities. This may cause significant setbacks with respect to the initiation of AQMPs, as many municipalities may require financial support. It is important to recognise that the availability of funding within municipalities for AQM depends on the prioritisation accorded AQM by the local political leadership. The core of the UK's NAQS was the setting of health-based standards for eight key air pollutants following a review by a government-commissioned expert panel (Ing *et al.*, 2001). In South Africa, the proposed national ambient air quality standards are based on international best practice and will undergo a process of public participation.

A key distinction between AQM planning in the UK and South Africa is that in the UK, local authorities are only required to designate AQMAs should adverse human exposure occur, whereas all South African municipalities are required to implement an AQMP, regardless of human exposure. A discussion on the morality of excluding areas where air pollution occurs, yet are unregulated owing to an absence of human habitation, is perhaps beyond the scope of this research. However, given the widespread lack of capacity in South African government environmental departments in terms of training and finances (Naiker, 2007), a tiered review and assessment approach based on human exposure rather than environmental exposure may allow poorer municipalities an opportunity to prioritise the implementation of any areas requiring an AQMP.

Where the UK system is based on a three-stage review and assessment process, it could be possible for South African district municipalities to adopt a condensed two-stage approach in order to minimise the costs and time involved. Stage one would essentially be a desktop study, involving the assimilation and analysis of information pertaining to industrial emissions inventories, topographical and climatological aspects, and other features of and affecting ambient air quality. Stage two would involve the monitoring and, where appropriate, modelling of ambient air quality where potential problems may arise (for example, in areas where industries operating licensed activities are located). This entire process could focus on human health as a trigger for action rather than general environmental health in order to focus on those areas that require the most urgent attention. In other words, areas exhibiting potentially or measured high pollution problems where human population density is also high should be addressed first, followed by those areas where population density is less, and finally focussing on areas where the environment may be affected, but human presence is negligible. Other, less affected areas could be attended to once the problems in the initial key areas have been addressed. This approach would be in accordance with Section 2(2) of NEMA, which states that environmental management must place people and their needs at the forefront of its concern (Republic of South Africa, 1998b).

In their study of the progress of AQM in rural authorities in England, Ing *et al*. (2001) describe the numerous challenges encountered by these authorities. Such challenges are influenced by: a lack of experience in dealing with air pollution issues accompanied by a lack of modelling and monitoring expertise; the insularity of government departments, an unwillingness to co-operate in the incorporation of air quality issues into other spheres of governance; a lack of funding emphasised through comparatively smaller budgets; capital outlay for the required equipment; and a small number of specialist staff.

It is apparent that these same factors will influence the majority of South African municipalities, and must be accounted for not only when developing policies and implementation programmes, but also when setting target deadlines. Although some of these aspects have already been identified in the three South African case studies, the inconsistency in the application of particular concepts or procedures, such as information dissemination and capacity building, identifies a need for a structured implementation methodology.

With a view towards the production of a generic AQMP framework for district municipalities, it is pertinent to summarise the key features of the AQMPs in the three metropolitan areas reviewed (Table 3.3).

Table 3.3: Aspects of air quality management prescribed by three existing AQMPs for metropolitan municipalities in South Africa.

Aspect of Air Quality Management	Johannesburg	Tshwane	eThekwini
Acknowledged links between the AQMP and municipal IDPs	X	X	X
A baseline assessment of air quality is required	X	X	X
An air quality management policy, based on the Constitution and Bill of Rights as well as environmental legislation, is explicitly stipulated	X	X	X
The development of local AQM objectives and thresholds are stipulated	X	X	X
An AQMS is required to guide the review and implementation of AQMPs, including short- and medium-term goals	X	X	X
Emissions quantification and reduction measures	X	X	X
An air quality management information system is required (note that Johannesburg and eThekwini refer to the national SAAQIS, whereas Tshwane refers to such a system at municipal level)		X	
Research initiatives	X	X	X
Capacity building	X	X	
AQMP approval and review process, probably derived from the AQMS	X	X	X
Active, transparent and traceable information dissemination to the public and all stakeholders			X

Table 3.3 indicates that there is a great deal of commonality between the various metropolitan AQMPs. Table 3.4 combines key aspects from the British system and the reviewed metropolitan municipal AQMPs in South Africa, with particular focus on the reason for their significance in developing a generic framework.

Table 3.4: Features of existing AQMPs requiring consideration for inclusion in the proposed generic framework.

Feature	Origin	Reason for Consideration
Review and assessment	United Kingdom	Although this feature of LAQM is a broader process rather than a feature of such, the merits of this system's phased analysis approach presents a systematic and controlled approach to baseline assessments. As South African municipalities are faced with financial and human resource constraints, a structured and simple system of monitoring and analysis is needed, and the review and assessment concept has been tried and tested as such in the UK.
Comprehensive emissions inventory and supporting database	United Kingdom, Johannesburg, Tshwane and eThekwini	A detailed database of emission sources, emission types (i.e. pollutants), contact information, locations, notable topography, population distribution dynamics, and meteorology is essential to the successful undertaking of a meaningful baseline assessment. Such a database will provide quantitative baseline information for the remainder of the air quality assessment, as well as the setting of future target emission levels. Any modelling undertaken as part of the air quality assessment will also rely upon input data generated from such a database.

Stakeholder consultation	United Kingdom,	The consultation of interested and affected parties with respect to the baseline assessment would reveal areas of concern to the public, as well as other areas that industries may feel need addressing (such as local by-laws and agreements). Such an exercise would also allow provision for the establishment of fora, during which time community stakeholders may engage with representatives from industry and the local municipality. The outcome of initial meetings would provide additional information to the baseline assessment, as well as ongoing remediation and management.
Air quality management policy	Johannesburg, Tshwane and eThekwini	From the outcome of the baseline assessment (i.e. emissions inventory and stakeholder consultation), an air quality management policy should be formed in order to guide the remainder of the AQM planning process through adherence to policy objectives and targets.
Air quality targets and objectives	United Kingdom, Johannesburg, Tshwane and eThekwini	The setting of objective ambient concentration limits is prescribed by national legislation, along with achievement timescales. However, individual municipalities may wish to improve upon these targets in accordance with Section 11(2) of the NEM:AQA, which states that municipalities may establish standards stricter than those prescribed in national and provincial legislation.
Mitigation and control measures	United Kingdom, Johannesburg, Tshwane and eThekwini	Analysis of the outcome of the baseline assessment and stakeholder consultation process would reveal particular areas and pollutants requiring remediation or management. As such, control and/or mitigation measures would need to be developed in order to undertake this task, particularly with respect to ambient target limits for specified pollutants. It must be reiterated that municipal air pollution control officers have the statutory right and power to require polluters or suspected polluters to submit an atmospheric impact report, as well as all scheduled (licensed) processes, and submit pollution prevention plans in accordance with Sections 29 and 30 of the NEM:AQA.
Co-operative governance facilitation programmes	United Kingdom, Johannesburg, Tshwane and eThekwini	Joint working between municipalities as well as between different departments within municipalities is essential to the continued effectiveness of mitigation and control measures, particularly in reference to multiple plans operating under an IDP. This can be illustrated by the example of traffic-related emissions, where local transport plans will have a direct impact upon air quality in relation to traffic volume and flow. If local departments of transport have sound working relationships with the team responsible for air quality planning, then a joint approach will likely mitigate against such planning. Co-operative governance programmes can be facilitated through a steering committee (as illustrated in DEFRA, 2003), consisting of members from different local government departments, neighbouring municipalities, and provincial government officials.

Air quality management system	Johannesburg, Tshwane and eThekwini	Johannesburg's AQMP report refers to an AQMS as the system which monitors the continuation of the emissions inventory, monitoring and modelled data, and meteorological data. Tshwane's explanation of an AQMS is ambiguous, but will be taken here as being similarly defined. The explicit development and regulation of such a system is perhaps unnecessary, given that such tasks are likely to be the responsibility of one or more people in an air quality team. Equally, however, making such a system an explicit component of an AQMP will ensure that the management of relevant data is properly controlled through designated responsibilities.
Air quality information system	Tshwane	Tshwane's AQMP report makes ambiguous reference to the establishment of an air quality information system. As the national SAAQIS is under development, this aspect is potentially redundant and shall be excluded from this study.
Reporting and reviewing system	United Kingdom, Johannesburg, Tshwane and eThekwini	This is an essential aspect of a management system as it stimulates continuous improvement and enhancement of the AQMP.
Information dissemination to stakeholders	United Kingdom and eThekwini	For the purpose of upholding the tenets of environmental governance as described in the preamble of NEMA (Republic of South Africa, 1998b), information dissemination to all interested and affected parties will promote accountability and transparency in the air quality management process. As such, the inclusion of effective systems in this regard is vital to the success of AQMPs.

3.6 AQMPs in the NEM:AQA and the National Framework

The NEM:AQA does not prescribe the content or structure of an AQMP beyond those already discussed in Chapter 2. To recapitulate, there are specific criteria that AQMPs must satisfy, which are to: improve air quality; identify and reduce negative air quality impacts on human health and the environment; address the effects of emissions from the use of fossil fuels, industrial sources and any point or non-point source of air pollution; implement South Africa's obligations in respect of international agreements; and give effect to best practice in air quality management (Republic of South Africa, 2004: Section 16).

The National Framework provides fairly extensive guidance on the content and structure of an AQMP at all levels of government (DEAT, 2007a:60-68). With regard to municipal AQMPs, this involves the setting of an air quality goal in accordance with relevant legislation and the South African Bill of Rights, the collection of current ambient air quality and emissions data, the consideration of control options for those substances measured or forecast to exceed the national or other standards, the implementation of these measures of intervention, the evaluation of the success of these measures, consideration of the implications of aspects of the AQMP in terms of climate change, and the development and re-implementation of control options (DEAT, 2007a:66 and 67).

Further to the statutory requirement for consideration of South Africa's international obligations in terms of air quality, it is important to acknowledge three significant international treaties: the Montreal Protocol (UNEP, 2000), which governs the reduction of ozone-depleting substances, the Stockholm Convention, which bans the production and use of persistent organic pollutants (POPs) (DEAT, 2007a), and the Kyoto Protocol and United Nations Framework Convention on Climate Change (UNFCCC, 1997), which encourages management and control of greenhouse gases (GHGs). With respect to these agreements, AQMPs are required to facilitate the monitoring and control of the manufacture and use of a number of pollutants explicit in each of the Protocols.

According to the National Framework (DEAT, 2007a, Section 2.4), South Africa's status as a developing nation does not require a binding commitment to cap or reduce GHG emissions under the Kyoto Protocol. However, to mitigate against future restrictions in this regard, it would be prudent to ensure a minimal impact insofar as GHGs are concerned, and thus include basic management thereof within the AQMP framework. Although South Africa ratified the Stockholm Convention in 2002, the POP known as DDT is still being used in the control of malaria vectors (provision is made in the Convention for such use should sufficient epidemiological evidence exist). No further discussion in this regard is necessary as the management of DDT is mediated through a Convention implementation plan, as well as the Africa Stockpiles Programme (DEAT, 2007a, Section 2.4.3.1), and therefore are not the province of AQMPs.

3.7 Generic Framework for an AQMP

Having reviewed AQMPs in the UK and South Africa, as well the requirements under the NEM:AQA and guidance provided by the National Framework, it is now possible to provide a suitable generic framework for district municipalities in South Africa. Components of existing AQMPs fell into one of two categories or phases: the first is the baseline situation, or review and assessment phase; and the second is the management and mitigation phase (City of Tshwane, undated; Scorgie *et al.*, 2003a; eThekwini Health and Norwegian Institute for Air Research, 2007). These two phases are recognised as important and form the first two phases of the proposed generic framework. However, a third phase, termed review and reporting, is introduced based on the identification of transparent information dissemination as an important criterion in the preparation of an AQMP (eThekwini Health and Norwegian Institute for Air Research, 2007). These stages are summarised in Figures 3.4, 3.5 and 3.6, and elaborated upon in the following sections.

3.7.1 Baseline Assessment Phase

The baseline assessment phase consists of two stages. The primary objectives of stage 1 are the compilation of a comprehensive emission inventory and identification of existing air quality management practices. Included in this stage is the assessment of future developments that will impact upon ambient air quality, and the subsequent identification of issues and areas of concern. An example of such a development may be a planned industrial park close to sensitive receptor areas, or an anticipated reduction in emissions from a particular source or type of source (such as commercial sugarcane burning). Stage 2 involves monitoring and, where appropriate, modelling of areas, sources and pollutants identified as known, potential or future problems with respect to ambient national, provincial and local standards. Ultimately, the baseline assessment concludes with the production of a document detailing all relevant information pertaining to existing air quality and air quality management practices in the municipality, as well as forecast issues of concern (Fig. 3.4 and 3.6).

Stage 1 of the baseline assessment should not commence until the scope of work is understood and appropriately accounted for. Although the formal establishment of the baseline assessment's objectives and methodology may not be necessary, the project should not be undertaken without a sound understanding of the required information. The emission inventory should contain information on source types and locations, emissions and emission rates, and contact information. A situation assessment that includes a discussion of factors that influence air pollution potential such as topography and climate, sensitive human and environmental receptor areas, a review of current and historic monitored air quality data, consideration of transboundary sources and impacts, impacts on climate change, and any other relevant influences should be included in Stage 1. A digital map produced and managed through a GIS may be the ideal medium in which to present a large proportion of this data.

Public participation forms an integral part of Stage 1 of the baseline assessment, particularly where the situation assessment is concerned. This should also reveal those areas where certain pollutants are considered a nuisance, health or environmental hazard by local residents, and will supplement emissions data obtained from industries. Analysis of the measured or estimated emissions and source geography, current AQM practices, as well as any existing health and risk assessment findings, will allow the identification of current and future trends in air quality and will lead to the demarcation of key impact zones, sources, and pollutants through the identification of air quality issues. This information will aid in the development of management and control strategies in the second phase of the AQMP.

An assessment of existing AQM practices, risk assessments and health studies will complement the situation assessment by providing data on how air pollution is managed, the effects of air pollution on human health in specific areas, and possible remediation measures already available or in place. A separate assessment of the skills capacity of the municipality in managing air pollution would also provide valuable input into assessing the level and amount of training and recruitment required for effective air quality management. Such an exercise should lead to active training and/or recruitment of skilled staff, although this may be supplemented in the short-term by the hiring of third parties to undertake the required work, provided longer-term investments in internal skills development are planned.

Once the situation assessment and emission inventory have been completed, the information contained therein requires verification through actual monitoring and, where necessary, dispersion modelling. Completion of the first stage of the baseline assessment should reveal those areas where ambient air quality standards are being, or are likely to be, exceeded, and as such the second stage should not be undertaken until the first stage has been completed. Public opinion obtained through participation procedures should also be acknowledged when undertaking the second stage, as this would confirm any reports or complaints made regarding air quality. Once this second stage has been completed, analysis of the results would feed into the second phase of the AQMP. Should the findings of the monitoring and modelling processes reveal that there are no exceedances of ambient air quality standards at present or in the foreseeable future, the municipality must prepare an AQMP based on ensuring that the ambient air quality standards will not be exceeded.

As all municipalities are required to develop and implement an AQMP, stage 1 is universal in its applicability. If no air quality issues are identified, or should existing quantitative emissions data indicate compliance with ambient standards, then there is little need to progress beyond the baseline assessment except to introduce a system of regular compliance monitoring. In this way, those municipalities with good air quality do not need to initiate comprehensive monitoring and modelling exercises, thus significantly reducing the associated costs.

3.7.2 Management and Mitigation Phase

Once the baseline assessment has been completed, an air quality management policy should be established, outlining the aims and objectives of the AQMP as it pertains to the municipality in question. The information contained in the emission inventory and gathered through stakeholder engagement will guide the AQM policy, particularly with reference to specific substances identified as requiring the implementation of reduction measures. As inferred, the aims and objectives of the AQMP will be guided by the policy, and these should be unambiguous and precise. Ambient air quality target concentrations have been prescribed by the NEM:AQA and National Framework, but municipalities should be aware of other pollutants not listed in current versions of the national legislation that may be having an impact in their jurisdiction. They should also be aware of the possible need to increase the stringency of prescribed ambient concentrations in accordance with Section 11(2) of the NEM:AQA should specific pollutants be particularly problematic.

Following the establishment of a guiding policy and objectives, the municipality would be required to investigate and implement appropriate control and mitigation measures for those pollutants identified as having a negative or potentially negative impact upon people or the environment. Such measures should act in accordance with the air quality policy's objectives, and should take account of targets and deadlines for ambient pollutant concentrations and other features of AQM published in the National Framework (DEAT, 2007a, Tables 27, 29, 31-37) or other government publications.

Actions may commence with those areas or pollutants having a detrimental effect on human health, and progress to those areas where human impacts may be absent but environmental damage occurs. Consideration must also be given to those pollutants regulated by the international agreements discussed in Section 3.5, as well as pollutants stemming from fossil fuels and industrial sources. This will allow for the addressing of pollutants contributing towards global climate change, which is a stipulation of the NEM:AQA and National Framework. It is also at this stage that those municipalities in which ambient air quality standards are not being exceeded are required to implement preventative measures to ensure the maintenance of good air quality.

A co-operative governance facilitation programme must be established in order to encourage the development of effective inter-departmental and inter-municipal relationships for the management and improvement of air quality, as stipulated in the National Framework, NEMA, the Municipal Systems Act, and the Constitution (DEAT, 2007a, Sections 2.2.2 and 5.1; Republic of South Africa, 1998b, Chapters 3 and 8; Republic of South Africa, 2000a, Section 25(1)a; Republic of South Africa, 1996, Section 41). Further to the discussion of co-operative governing initiatives in Table 3.5, these relationships would need to address any air quality issues that the designated municipal department (e.g. Environmental Health) is not able to manage on its own. For example, correct infrastructure planning could aid in the dissipation of traffic-related air pollution if the local transport department is involved in the AQMP. Perhaps more importantly, such relationships will also ensure that those areas in which transboundary pollution occurs will not be ignored in the mistaken premise that another authority will take responsibility.

Although the introduction of a system to formally manage the flow of data from monitoring, modelling and reduction initiatives may appear unnecessary, it is important that regular and reliable information is acquired, processed, and stored so that trends in air quality dynamics can be observed and enacted upon. The Johannesburg and eThekwini AQMPs refer to this system as an 'air quality management system', but this introduces an element of ambiguity when considering that this resembles a plausible synonym for an AQMP. As such, it may be better to term this a 'data management system', where personnel are delegated specific responsibilities that ensure regularity and reliability in air quality data management.

The outcome of the management and mitigation phase is a document which records the control interventions implemented by the municipality. This document will be subject to review and change at regular intervals according to the third and final phase of the AQMP framework (Fig. 3.5 and 3.6).

3.7.3 Reviewing and Reporting Phase

An essential part of any environmental management plan is the reporting of progress, interventions, developments, and results to all stakeholders, and this similarly applies to AQMPs. The Municipal Systems Act requires all municipalities to report annually on both the financial and progress performance of its IDP, and thus it follows that annual air quality reports must be completed for inclusion into the IDP report (Republic of South Africa, 2000a: Sections 46 - 48). This is in accordance with the NEM:AQA, which stipulates a need for regular reporting on air quality (Republic of South Africa, 2004: Sections 7(2)g and 17). The information contained in such a report is likely to present trends in measured data over the reporting period, as well as qualitative analysis of the implementation progress of the AQMP.

In order to assist with interim monitoring of AQMP implementation progress, bi-annual or quarterly fora or workshops held between local government departments involved in the AQM process and other stakeholders are recommended, which may also encourage more active participation from industries and the public. Any reports published, whether on an annual or more frequent basis, must be available for public viewing and comment, and should only contain information that is accurate, transparent, and for which a government team, department or individual is accountable. This is to ensure direct compliance with the principles of good governance set out in NEMA (Republic of South Africa, 1998b, Section 2(4)).

A final component of the reviewing and reporting phase of an AQMP is the dissemination of information to the public and all relevant stakeholders. It is important for the distributing body to use appropriate media for dissemination, particularly with respect to those communities exhibiting a low literacy level. In such circumstances, for example, it may be more appropriate for verbal presentation and discussion of information rather than leaflet or email distribution. The distributing body, likely to be the local government department responsible for the management of the AQMP, must be aware of stakeholder needs in this regard, and should ensure that all interested and affected parties are given equal opportunities to examine, discuss and respond to information generated from the AQMP (Fig. 3.5 and 3.6).

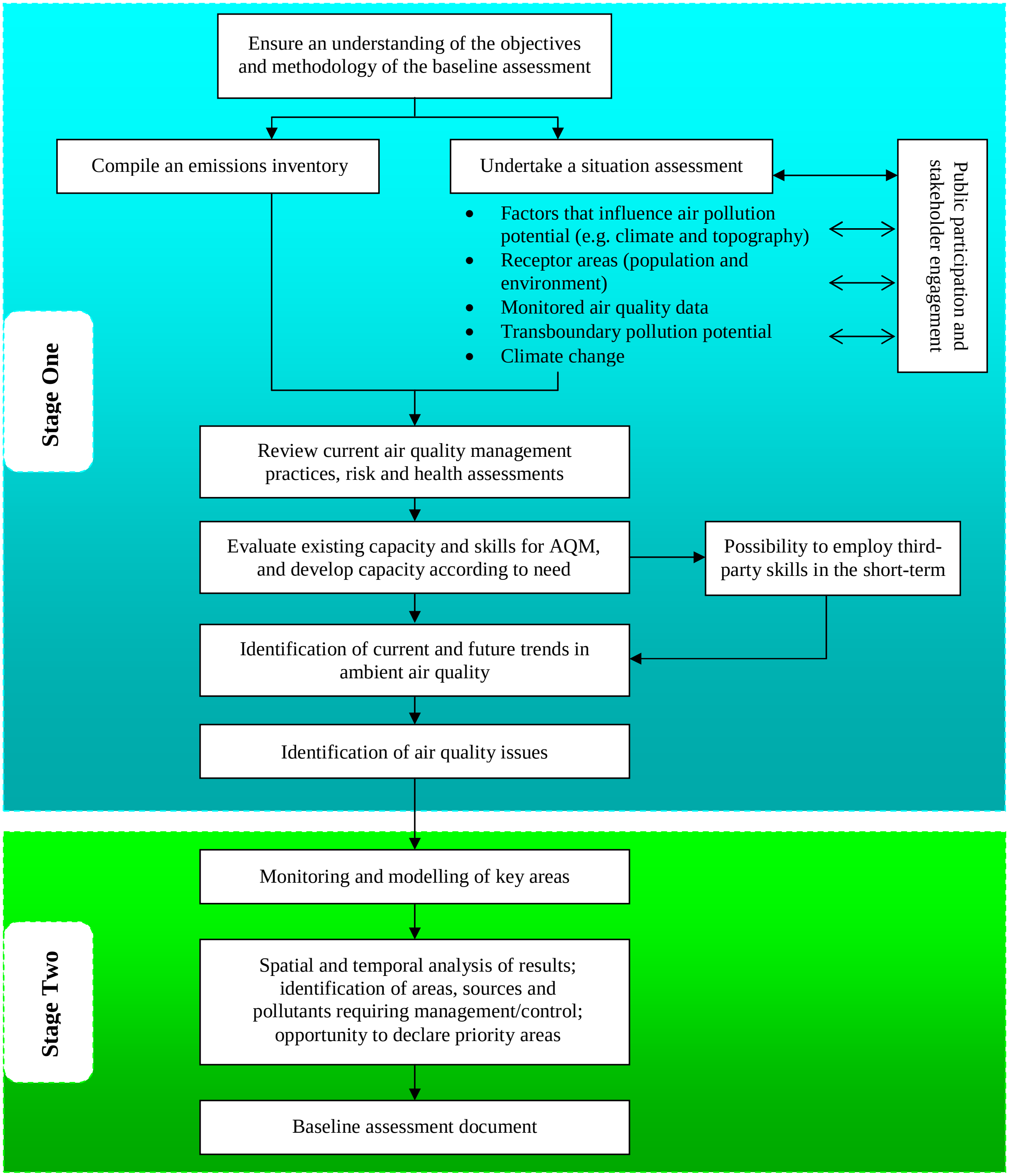

Figure 3.4: Proposed Generic Framework for District Municipality AQMP: Phase One, Baseline Assessment

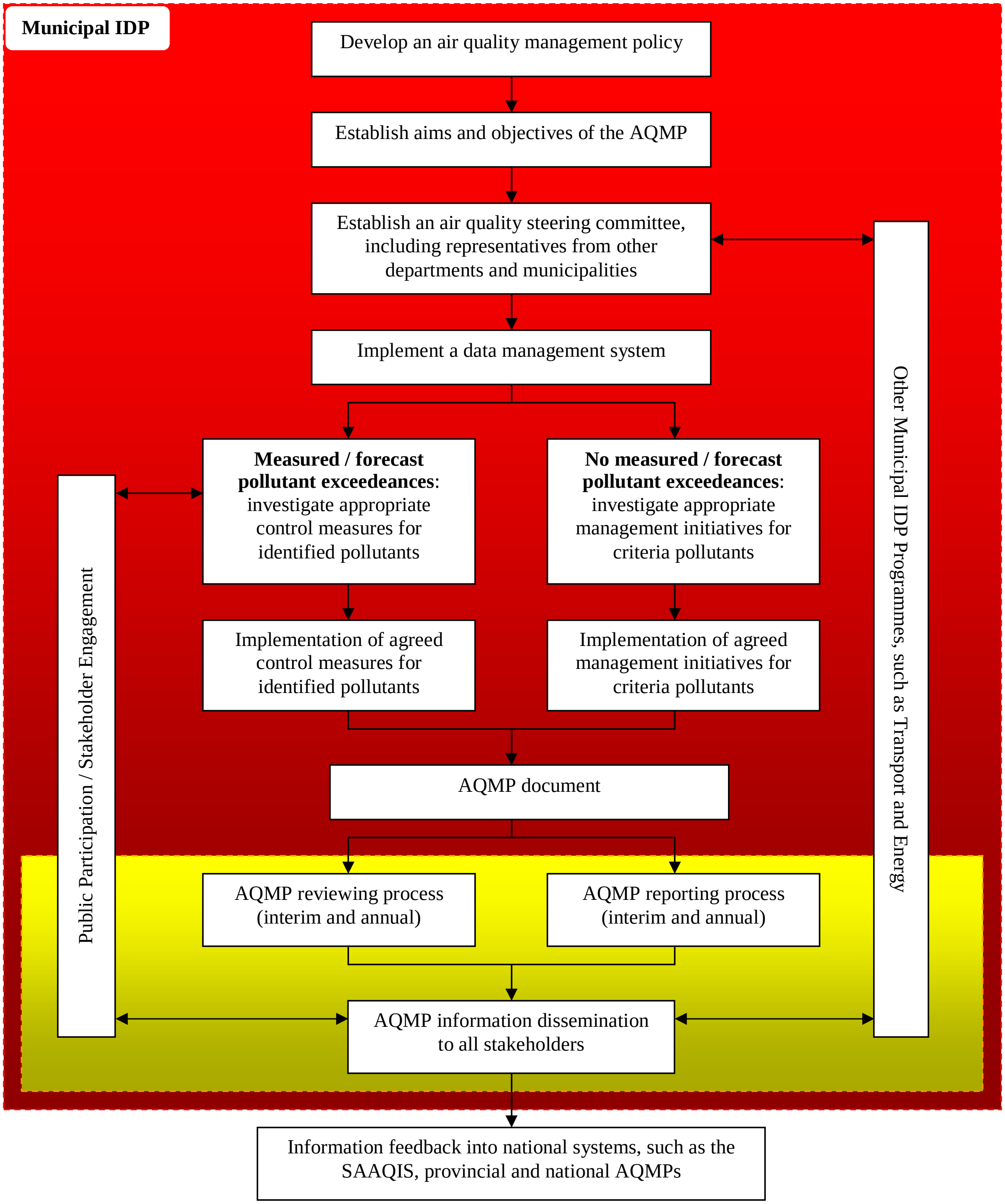

Figure 3.5: Proposed Generic Framework for District Municipality AQMP: Phase 2, Management and Mitigation (red); and Phase 3, Reviewing and Reporting (orange)

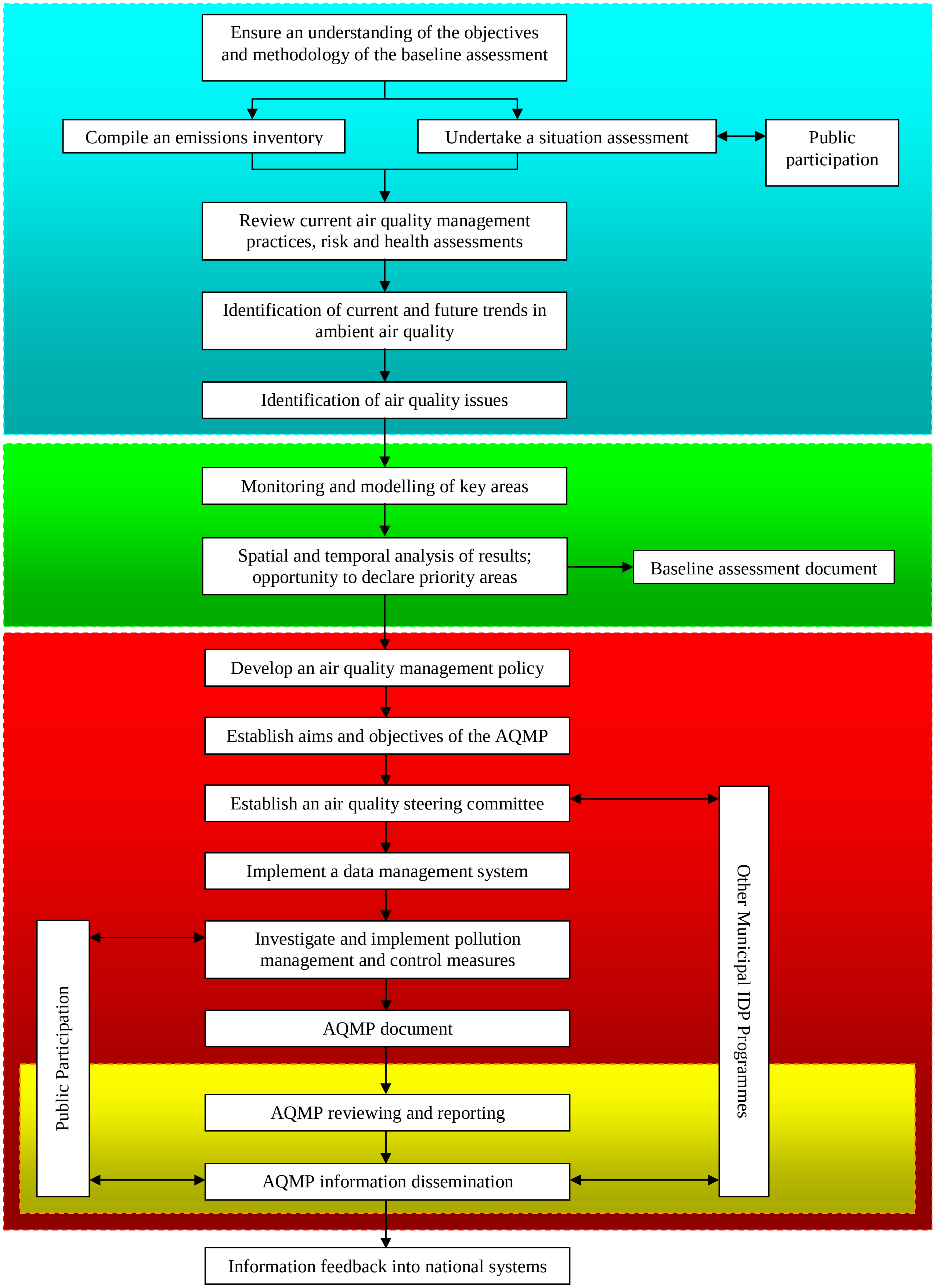

Figure 3.6: Proposed Generic Framework for District Municipality AQMP: Simplified

CHAPTER 4
TESTING THE PROPOSED GENERIC AQMP FRAMEWORK AT ILEMBE DISTRICT MUNICIPALITY

4.1 Introduction

The aim of this chapter is to apply stage 1 of the baseline assessment developed in Chapter 3 (Fig. 3.4) to the iLembe District Municipality. Following this framework, the structure of Chapter 4 is thus as follows: Section 4.2 recapitulates on the objectives and methodology of stage 1; Section 4.3 presents a situation assessment of iLembe; Section 4.4 discusses an emission inventory for the municipality; Section 4.5 reviews current AQM practices, risk and health assessments; Section 4.6 identifies current and future trends in ambient air quality in the municipality; and Section 4.7 identifies iLembe's air quality issues. Finally, Section 4.8 highlights some of the difficulties encountered in striving towards an AQMP for iLembe. All figures in this chapter are repeated in Appendix 1 in larger scale.

4.2. Aims and Objectives of Stage 1 of the Baseline Assessment

The primary objectives of stage 1 are the compilation of an emission inventory, the identification of existing AQM practices, and the identification of areas and issues of concern (Section 3.7.1). In order to achieve these aims, a situation assessment of the study area must be undertaken, where all aspects of the study area that can influence or be influenced by ambient air quality must be considered.

Once the remaining steps have been addressed (see Section 4.1), the identification of air quality issues must lead to the designation and allocation of appropriate ambient monitoring and modelling. Public participation has not been addressed in this study, as this was not part of the original study design or study objectives. However, it is recognised that public participation is an essential component of an AQMP and must be undertaken prior to the initiation of stage 2.

4.3 iLembe Situation Assessment

4.3.1 Location

iLembe is a coastal district municipality situated at the north-east of eThekwini Metropolitan Municipality and south-west of uThungulu District Municipality in the province of KwaZulu-Natal, South Africa (Fig. 4.1).

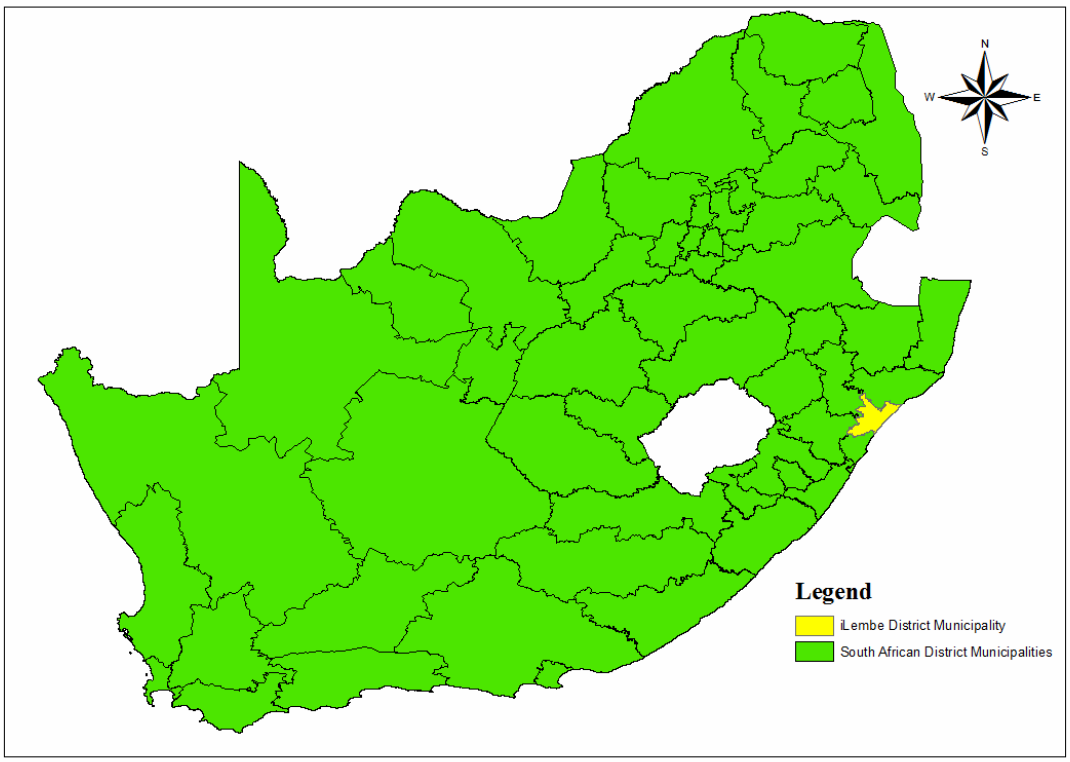

Figure 4.1: Map showing the location of iLembe District Municipality in South Africa (source: Statistics South Africa, 2001)

The inland neighbouring municipalities are uMzinyathi District Municipality to the northwest, and uMgungundlovu District Municipality to the southwest. iLembe is the smallest district in KwaZulu-Natal, with an area of approximately 3 260 km^2. There are four local municipalities which together comprise iLembe, namely eNdondakusuka to the north-east, Maphumulo in the north-west, KwaDukuza in the east, and Ndwedwe in the south-west (iLembe District Municipality, 2006:8) (Fig. 4.2).

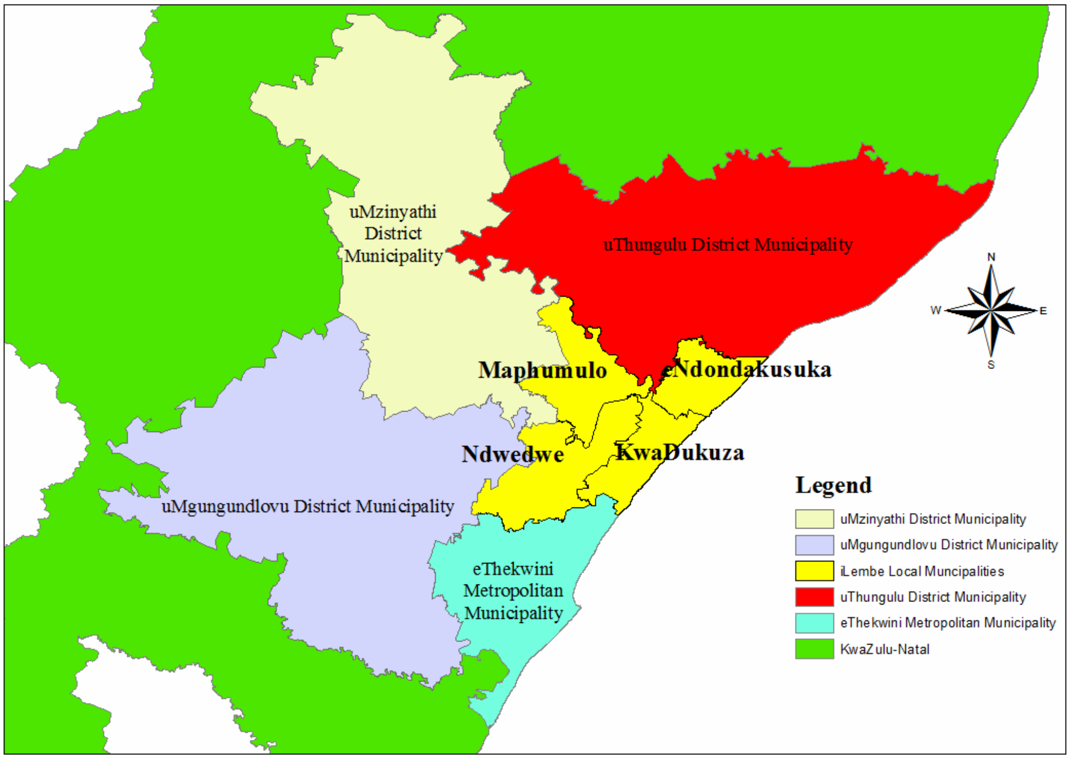

Figure 4.2: Map showing iLembe local municipalities and neighbouring district municipalities (source: Statistics South Africa, 2001)

4.3.2 Topography

Figure 4.3 presents a slope gradient analysis for iLembe, overlain by the river systems. Colour intensity represents slope steepness on a sliding scale; thus darker reds indicate steep slopes, and lighter reds indicate gentle slopes. It is apparent from this figure that the coastal half of the district consists of undulating land of shallow gradient, whereas the inland half of the district is significantly more rugged, with steep gradients particularly in the north. There is a clear and prominent elevation change along a southwest-northeast axis, and approximately halfway between the coastline and the western border of the municipality. Rivers dissect the municipality by flowing at right angles to the coastline. This should be noted for potential impacts upon meteorology and hence pollution dispersion. The two largest rivers are the Tugela and uMvoti rivers.

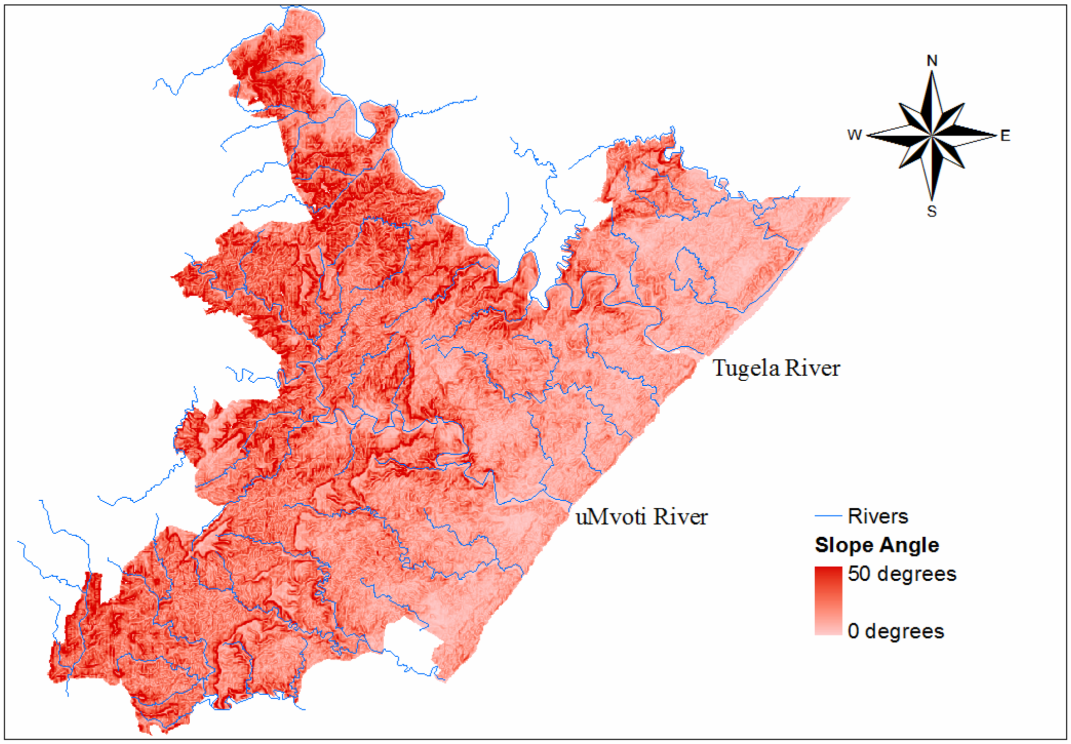

Figure 4.3: Slope analysis of iLembe with river systems (source: iLembe GIS Database)

4.3.3 Climate

4.3.3.1 Synoptic Climatology

In terms of prevailing meteorology and its impact on air pollution potential (APP), there are three dominant synoptic regimes that have been identified for the KwaZulu-Natal region, namely the established high-pressure system, a pre-frontal situation, and a post-frontal situation (Scott and Diab, 2000). In each of these stages, there are a number of characteristics that affect APP along the country's east coast. The established high-pressure system, characterised by anti-cyclonic circulations over the subcontinent, typically generates light, north-easterly winds, low to moderate mixing depths caused by upper air subsidence inversions, and nocturnal surface inversions. During such conditions, APP along iLembe's coastal belt is generally moderate but may be higher in the inland parts of the district due to more established inversions and lighter winds (Preston-Whyte and Diab, 1980; Diab *et al.*, 1991).

The pre-frontal stage is often typified by north-westerly winds as the anticyclone migrates eastwards over the Indian Ocean and a temperate cyclone approaches the south-western coast. These offshore winds, known as Berg winds owing to their directional approach from the Drakensberg mountains, can be accompanied by very low mixing depths as the along-coast pressure gradient increases subsidence ahead of the approaching low-pressure system. This is when APP is at its highest and air pollution dispersion potential correspondingly at its lowest (Preston-Whyte and Diab, 1980; Diab *et al.*, 1991).

As the low-pressure system approaches and passes, the prevailing wind direction and strength changes from a light to moderate north-westerly to a moderate to strong south-westerly, often accompanied by rainfall. The subsidence inversion lifts or dissipates, and the APP falls. The passage of a low-pressure system prevents the development of mesoscale circulations owing to the strong south-westerly winds (Preston-Whyte and Diab, 1980; Diab *et al.*, 1991). Figure 4.4 depicts these three synoptic conditions, where a) represents the established anticyclone, b) represents the pre-frontal conditions, and c) the post-frontal situation.

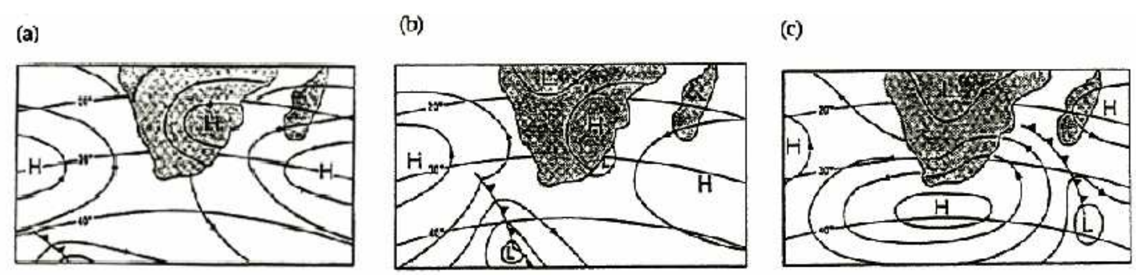

Figure 4.4: Synoptic sequence of APP conditions over South Africa (adapted from Scott and Diab, 2000)

It is clear that the meteorological progression of an established high-pressure system to pre-frontal conditions increases APP by lowering the elevated inversion layer, and that ambient air pollution will be highest at this time. Conversely, APP will be lowest following the passage of a low-pressure system. During the winter months, stable anti-cyclonic conditions prevail over the region, thus raising the average seasonal APP. Summer months are characterised by more turbulent convection storms and the passage of low-pressure systems, therefore lowering the average seasonal APP (Preston-Whyte and Diab, 1980; Diab *et al.,* 1991).

4.3.3.2 Local Climate

Local weather is further influenced by topographic features such as mountains and valleys, and proximity to the coast. Tyson and Preston-Whyte (1974) explored the influence of regional topography on wind systems in KwaZulu-Natal, specifically studying diurnal variations in the circulations and the influence of valley positioning on these circulations.

According to their observations, as well as the evidence from Figure 4.3, the majority of rivers in KwaZulu-Natal trend northwest-southeast, a fact which has considerable influence on local circulations in iLembe. Stable anti-cyclonic winter conditions lead to the development of well-defined local air circulations in river valleys, generally observed as two systems: firstly, the down-valley mountain wind and return anti-mountain circulation; secondly, the regional mountain-plain wind (Tyson and Preston-Whyte, 1972). Although the mountain-plain wind generally occurs further inland than iLembe's western border as a result of strong gradient winds preventing them from penetrating the coastal belt, they may nevertheless be responsible for transporting pollution generated inland of iLembe into the district.

During fair, stable conditions, north-westerly and south-easterly winds can be generated by the cycle of daytime solar heating and nocturnal cooling – sometimes known as land and sea breezes respectively. When regional mountain-plain long-range transportation reaches the coast, there is a chance that daytime onshore sea breezes may recirculate pollution back towards iLembe, resulting in the inland emissions having a double impact on the municipality. Typically, sea breezes will develop during the morning hours and prevail throughout the day, and land breezes will develop in the late afternoon or evening

(Tyson and Preston-Whyte, 1972). As atmospheric energy input increases during summer, it becomes difficult to differentiate between valley-mountain and gradient winds (localised convection storms will also have variable impacts at the local scale), but winter shows a higher proliferation of valley-mountain winds as coastal-maritime temperature gradients decrease (Tyson and Preston-Whyte, 1972).

Figure 4.5 shows the impact of two types of topographic configurations evident in iLembe on land breezes (valleys parallel to the slope in the inland region, and northwest-southeast valleys in the coastal belt). It shows that valleys at right angles to the slope and wind direction induce local circulation perpendicular to the wind direction, whereas valleys parallel to the slope and wind direction induce local valley-mountain circulation. iLembe's river systems flow perpendicular to the coastline (Fig. 4.3), therefore the large majority of valleys in the coastal belt will experience local wind circulations similar to those of the bottom image, where backflows will recirculate atmospheric pollution. Localised areas where river direction runs parallel to the coastline will experience flows similar to those indicated in the top image.

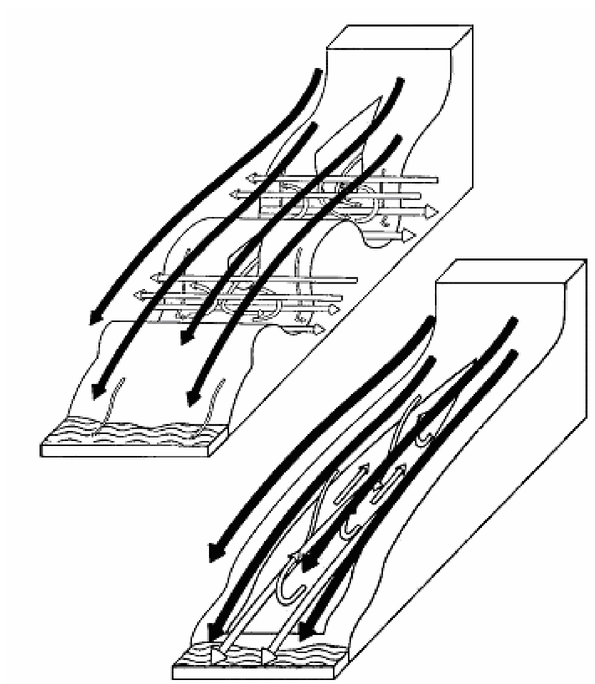

Figure 4.5: Diagram of land breezes with parallel valleys at right angles to the slope (top) and valleys parallel to the slope (bottom) (Tyson and Preston-Whyte, 1972:644)

The region's interior will differ depending on the strength of the temperature gradient induced by the daily warming and cooling of the land and sea. The effect of the sudden change in topography approximately halfway between the coastline and the western boundary is uncertain, and may entirely negate the effect of the temperature gradient. If such is the case, then valley-mountain circulation is likely, where stable conditions may cycle emissions between the valleys and higher areas. As lower areas may also be subjected to strong temperature inversions during stable weather conditions, the effects of pollution sources in valleys are likely to be worse than those sources situated on plateaus and higher altitudes.

In the context of ambient air quality, the circulations discussed will have varying impacts on the dispersion of air pollution based on location, season, and synoptic conditions. In anticipation of initiating an AQM system and developing AQM and control initiatives, it is important that meteorological factors are taken into account. Figure 3.4 in Chapter 3 prescribes the monitoring and modelling of air quality in areas of concern, and meteorological monitoring and modelling will be integral to understanding APP and ambient air quality.

4.3.4 Population Distribution

According to the IDP (iLembe District Municipality, 2006), Maphumulo, the southwest areas of Ndwedwe, and the coastal and inland areas of eNdondakusuka are almost entirely traditional tribal authority areas, characterised by subsistence farming activities. The northern areas of Ndwedwe, the central corridor of eNdondakusuka and KwaDukuza are the commercial farming hubs of the region, and include the urban centres of the municipality (Fig. 4.6). The urban areas are characterised by mixed land use, with a high level of infrastructural and service development. This has attracted industries, which are concentrated in Stanger, Isithebe, and Mandeni (iLembe District Municipality, 2006:9) (Fig. 4.6). Other urbanised areas include Nkwazi (Zinkwazi), Ndwedwe town, and Ballito. The population is fairly evenly distributed amongst the four local municipalities (Fig. 4.7), with the largest number of people residing in KwaDukuza and Ndwedwe municipalities (Statistics South Africa, 2001). Although Ndwedwe is predominantly rural in terms of development, its population is proportionate to its size as the largest municipality in iLembe.

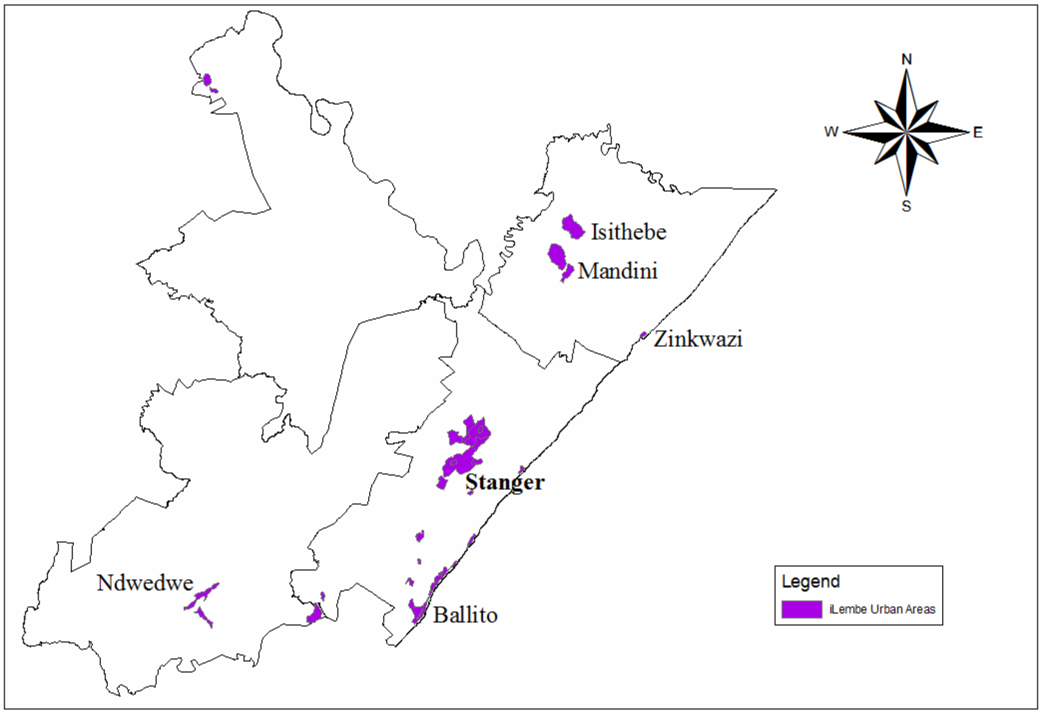

Figure 4.6: iLembe urban centres (source: iLembe GIS Database)

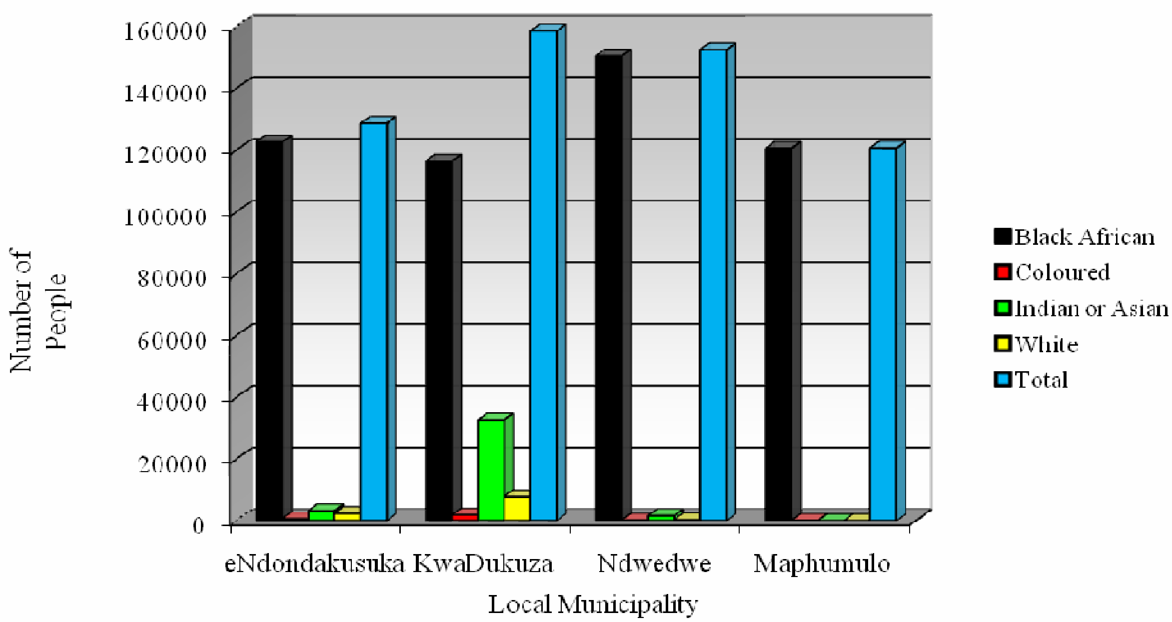

Figure 4.7: Bar graph showing population distribution by race and local municipality in iLembe (source: Statistics South Africa, 2001)

Table 4.1 shows population distribution data, including population densities for the key areas identified. Similar information is presented graphically in Figure 4.8. The Census of 2001 denotes small geographic areas as ‘sub-places’, and this is reflected in both Table 4.1 and Figure 4.8.

Table 4.1: Population data for iLembe (adapted from Statistics South Africa, 2001)

Local Municipality	Sub-Place	Population	Area (km^2)	Population Density ($people.km^{-2}$)
Maphumulo	Ntunjambili	7 908	33.6	235.4
	Ekungobeni	6 932	43.1	160.8
Ndwedwe	Hlomantethe	11 574	98.1	117.9
	Ndwedwe	2 089	14.1	148.2
	Shangase Village	7 795	72.1	108.1
eNdondakusuka	Isithebe	9 627	13.7	702.7
	Endlondlweni	8 729	9.8	890.7
	Mandeni	1 763	9.1	193.7
	Sundumbili	21 378	3.8	5625.8
KwaDukuza	Darnall	2 769	7.5	369.2
	Shakaville	8 501	4.2	2024.1
	Stanger	11 199	9.5	1178.8
	Groutville	6 109	3.1	1970.7

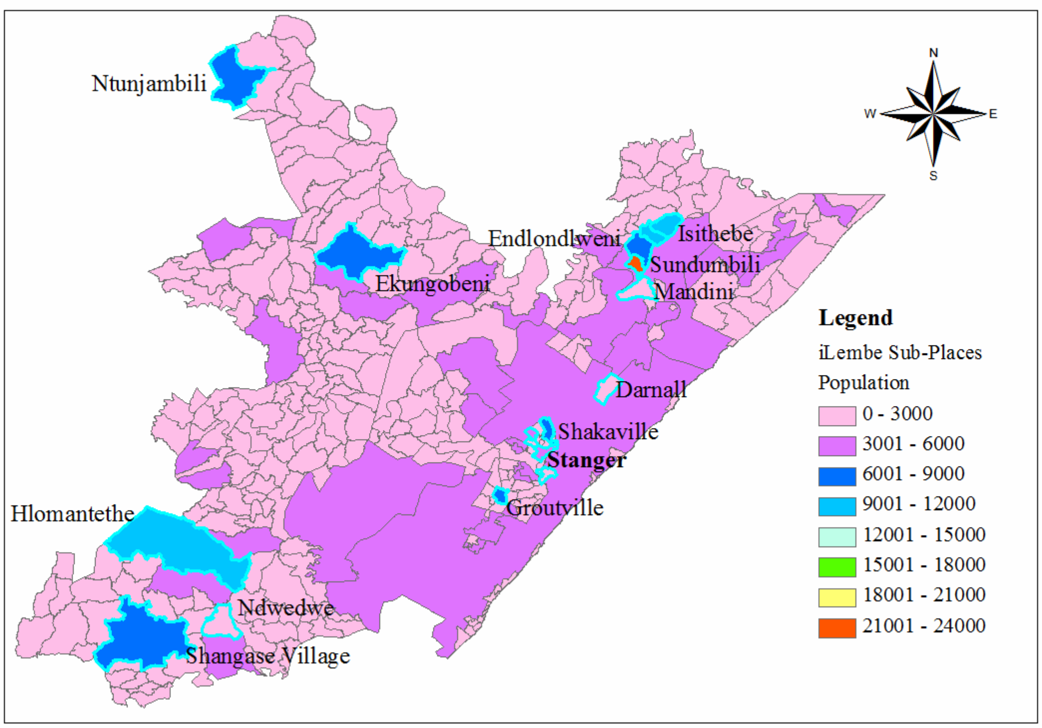

Figure 4.8: iLembe sub-place populations (source: Statistics South Africa, 2001)

Where Figure 4.8 indicates multiple sub-places for Stanger and Isithebe, these have been amalgamated into single areas in Table 4.1 in order to reflect more accurately the urban population of Stanger town and Isithebe respectively. Population density figures were calculated using area values from Statistics South Africa (2001). Higher population densities imply a greater likelihood of pollution sources, and a density analysis provides an indication of where sensitive receptors are likely to be located.

4.4 Emission Inventory

4.4.1 Provincial Emission Inventory

The KwaZulu-Natal Department of Agriculture and Environmental Affairs (DAEA) commissioned an independent environmental consultancy, Zanokuhle Environmental Services, to investigate and compile a provincial emissions inventory (Mjoli *et al.*, 2007). The study focused on seven primary pollutants identified by the DAEA, namely CO (carbon monoxide), CO_2 (carbon dioxide), SO_2 (sulphur dioxide), NO_X (oxides of nitrogen), Pb (lead), TOC (total organic compounds, or total volatile organic compounds), and PM (particulate matter). Lack of data availability resulted in emission information being gathered from only four industries and the district's total vehicle fleet. Table 4.2 presents these data as produced by Mjoli *et al.* (2007). Information on how these data were calculated was unavailable.

Table 4.2: iLembe emission inventory (adapted from Mjoli *et al.*, 2007)

Sector	Source	Nature of Industry	CO_2 (tons/ year)	CO (tons/ year)	SO_2 (tons/ year)	NO_X (tons/ year)	PM (tons/ year)	Pb (tons/ year)	TOC (tons/ year)
Industry	Sappi Mandeni	Paper mill		2978.4	2409	620.9	331.1	0.6	4.8
	Gledhow Mill	Sugar mill	53973	143	0.02	421	575	0.4	3.2
	United National Breweries	Brewery		27.3	75.1	27.2	55.1		6.6
	Bayer Ltd (Lanxess)	Chemical products		0.55	7.95	2.91	0.22		
		Subtotal	**53973**	**3149.2**	**2492.1**	**1072**	**961.5**	**1.03**	**14.6**
Vehicles				4696.5	33.3	514.6	93.5		859.2
		Total	**53973**	**7845.6**	**2525.4**	**1586.6**	**1055**	**1.03**	**873.8**

Owing to the paucity of data on industrial emissions, the information from the four industries identified cannot be used in any meaningful way as it cannot be related to broader impacts on ambient air quality, except in cases where these industries are geographically isolated. Although the vehicle emissions are useful in that they provide an overview of total vehicle contributions to district-wide ambient air pollution, the data have limited use owing to the lack of location-specific (i.e. national roads versus primary roads, etc.), time-averaged measurements from specific sources.

4.4.2 Industrial Point Sources

Further information on additional industrial sources is available from a study by Seppings (2005). Seppings was tasked with undertaking an environmental risk assessment for iLembe, a significant portion of which related to air quality and atmospheric emissions. In her study, Seppings visited a large number of potentially significant industries in eNdondakusuka and KwaDukuza, focusing on those activities within each individual operation that may have an impact on ambient air quality (Seppings, 2005:7-54). Tables 4.3 and 4.4 present summarised data for eNdondakusuka and KwaDukuza, where those activities requiring or already in possession of a registration certificate under the APPA owing to the operation of scheduled processes (listed activities) are noted.

Table 4.3: Scheduled processes in eNdondakusuka (source: Seppings, 2005)

Industry (Type)	Sampled by Seppings	Scheduled Processes	Registration Certificate	Possible Emissions
Amatikulu (sugar mill)	Yes	Bagasse incineration processes; power generation processes	Yes	PM; ash; SO_2; NO_X; VOCs; odorous substances
SAPPI KRAFT (paper mill)	Yes	Paper and pulp processes	Yes	PM; SO_2; NO_X; VOCs; CO
Inkunzi (foundry)	Yes	Iron and steel processes	Yes	VOCs; odorous substances; PM; fumes; dioxins; persistent organo-halogens; heavy metals
Chemical industry	Yes	Power generation processes	No	VOCs, heavy metals, CO, asbestos, manganese, silica, NO_X, fluorine compounds, O_3
SA Melting	No	Lead processes	Yes	Pb; CO and CO_2
Scaw Metals	No	Iron and steel processes	Yes	CO and CO_2
Tarmac No. 5	No	Macadam preparation processes	Yes	PM
Bayer (Pty) Ltd	No	Amine processes	Yes	VOCs

Table 4.4: Scheduled processes in KwaDukuza (source: Seppings, 2005)

Industry (Type)	**Sampled by Seppings**	**Scheduled Processes**	**Registration Certificate**	**Possible Emissions**
Gledhow (sugar mill)	Yes	Bagasse incineration processes; power generation processes	Yes	PM; ash; SO_2; NO_X; VOCs; odorous substances
Darnall (sugar mill)	Yes	Bagasse incineration processes; power generation processes	Yes	PM; ash; SO_2; NO_X; VOCs; odorous substances
SAPPI Fine Paper (paper manufacture)	Yes	Paper and pulp processes	Yes	$PM_{2.5}$; SO_2; NO_X; VOCs; CO
Wood products	Yes	Wood burning and wood-drying processes	No	VOCs and PM
Metal industry	Yes	Copper processes	No	CO and CO_2
Metal industry	Yes	Galvanising processes	No	CO and CO_2
Metal/Plastic industry	Yes	Galvanising processes; metal spray processes	No	VOCs and NO_X; CO and CO_2

It is noted that the Seppings (2005) study identified 15 industries conducting scheduled processes, not all of which were operating with a registration certificate. Industrial emissions are therefore expected to be far higher than those reflected in Table 4.2. Unfortunately the Seppings (2005) study did not record actual emissions.

The most recent emission data is that available from the APPA registration certificate review project. An independent air quality consultancy in Johannesburg, Airshed Planning Professionals, was appointed to carry out a national review project through which registration certificates issued under APPA were reviewed and re-issued as atmospheric emission licenses (AELs) under the NEM:AQA (DEAT, 2007b). This database shows that there are 16 industries in iLembe which operate under registration certificates, 11 of which are located in KwaDukuza (Scott, 2007: pers. comm.). Included are paper and sugar mills, metal refineries, and state-owned hospitals.

Of the 16 industries identified in DEAT's registration certificate database for iLembe (DEAT, 2007b) (Section 4.4.3), only 10 are accounted for in Seppings' study. This contrasts further with the eight operators identified in iLembe's database (see Figure 4.9). Comparison of Seppings' results and the data obtained from DEAT's registration certificate database indicate that some of the industries identified by Seppings as having registration certificates (such as Scaw Metals and SA Melting) either no longer exist or were incorrectly identified. As the APPA review process is more recent and reliable, these data should be given precedence over other studies. However, as geographic data for the outstanding industries from DEAT's database have not been recorded, the figures hereafter only include those industries acknowledged in the municipal database.

There are a number of potential atmospheric pollution emitters located throughout the district (Fig. 4.9). Fixed-location sources of pollution, known as 'point' sources, were identified using two datasets from the iLembe GIS database which record industrial and commercial activities. These datasets were enhanced through the identification of those activities which are in possession of registration certificates issued under the APPA scheduled processes control regime, the names and locations for which were obtained from the national registration certificate electronic database (see Section 4.4.3).

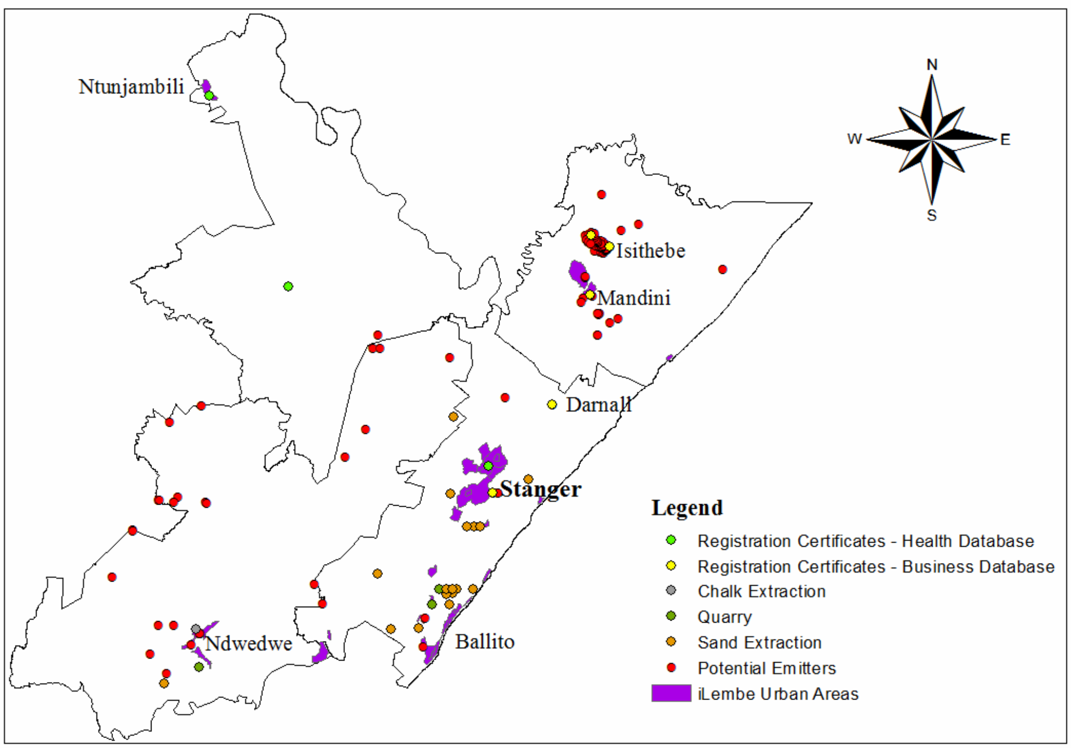

Figure 4.9: Location of potential anthropogenic point source emitters (source: iLembe GIS Database)

Eight of the industries indicated on Figure 4.9 are recorded as requiring or possessing registration certificates. Three of these, identified by green dots on the figure, are regional state-run hospitals, whereas those operations identified by yellow dots are industries. In eNdondakusuka this includes Inkunzi Foundry and Metso Minerals in Isithebe (both involving metal refining), and a Sappi paper mill in Mandeni; Darnall and Gledhow sugar mills in Darnall and Stanger respectively, as well as Stanger Provincial Hospital in KwaDukuza; and Umphumulo and Untunjambili provincial hospitals in Maphumulo.

Additionally, the Isithebe/Mandeni area also hosts a number of other industries, the majority of which are manufacturers. Included in this count are furniture manufacturers, textiles, metal and plastic manufacturers, engineering/vehicle workshops, and chemical manufacturers. In Stanger, furniture manufacturers, metal and plastic manufacturers, and engineering/ vehicle workshops are noted. Emissions from the different operations include VOCs such as toluene, formaldehyde and xylenes, NO_X, CO, SO_2, PM, and heavy metals such as cadmium and nickel (Seppings, 2005). Although these industries may not require registration certificates under the APPA, it is possible that revision of the National Framework may incorporate some of these processes as listed activities.

It is likely that the communities in Isithebe, Mandeni, Sundumbili, Stanger, and Shakaville will be affected by similar types of pollutants, given the similar types of industries located nearby (Tables 4.3 and 4.4). In particular reference to the identified scheduled processes (Seppings, 2005; DEAT, 2007b), these will include particulates, SO_X, NO_X, VOCs, CO and CO_2, and odorous substances. Certain areas of Isithebe and Mandeni are additionally likely to be affected by heavy metals, persistent organo-halogens, asbestos, and lead. Reviewed in the context of ambient pollution management and the NEM:AQA, all seven common pollutants identified for ambient standards are likely to be found in these areas (where ozone will form as a result of photochemical reactions between oxides of nitrogen and oxygen) (Table 2.1). The effects of smaller-scale industrial processes will compound these broad pollutant groups from an ambient perspective, and will have more localised effects in most cases.

4.4.3 Vehicular Emissions

In addition to the point sources, vehicular traffic also contributes towards poor air quality. National and primary road networks are likely to contribute gaseous and combustion-derived particulate matter, whereas secondary and community road networks in rural areas are likely to contribute primarily towards particulate matter loading. Road networks in iLembe are shown in Figure 4.10. It is therefore expected that road-based emissions in south-west Ndwedwe, most of Maphumulo, and northern eNdondakusuka will be primarily particulate in nature (i.e. dust from the roads), whereas road-based emissions in southern eNdondakusuka, most of KwaDukuza, and northern and north-eastern Ndwedwe will be a mixture of particulate matter and gaseous emissions.

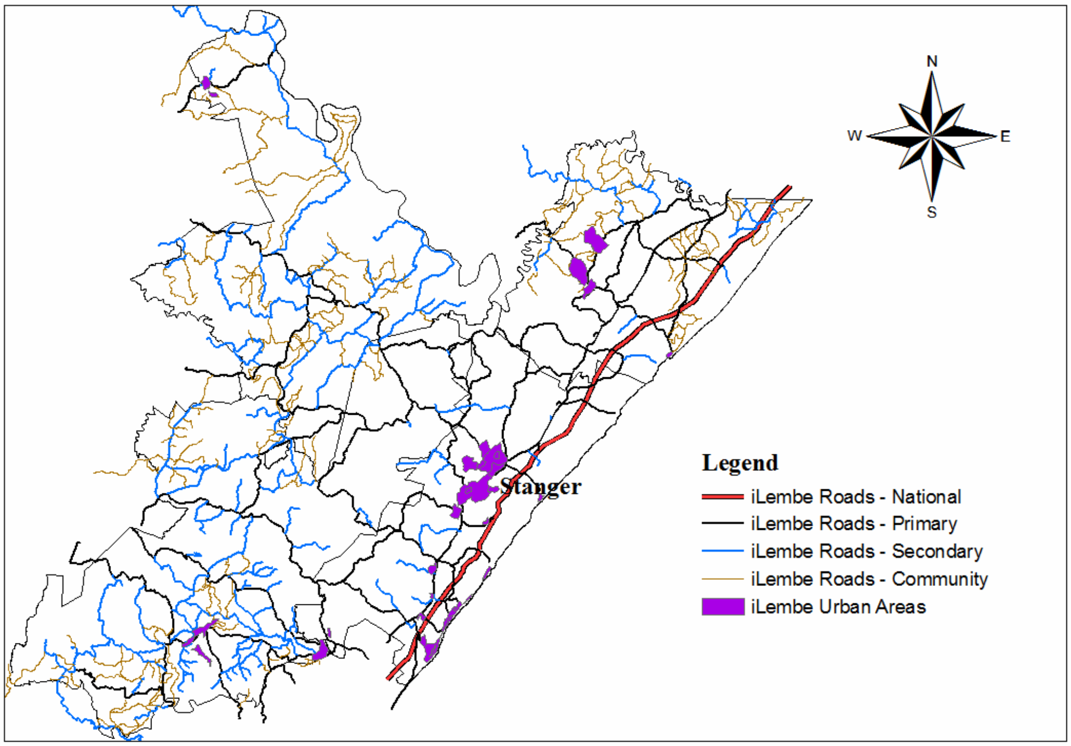

Figure 4.10: iLembe road network (source: iLembe GIS Database)

From Figure 4.10, it is apparent that the individual urban areas will experience different vehicle emission issues. Ndwedwe is primarily accessed by community and secondary roads, which will result in a relatively high proportion of particulate pollutants. In contrast, Stanger is accessed by the national road running parallel to the coastline, as well as primary and some secondary roads, which will likely result in a high proportion of gaseous emissions. The movement of hauliers between large industrial complexes and sugarcane farms will have significant impact on rural and urban communities, but this will vary according to the distribution and concentration of such sites, as well as the type of road surface upon which hauliers must travel (i.e. ambient suspended particulates will greatly increase should trucks have to travel along compacted dirt roads).

Many of the point source emitters identified in Figure 4.9 are located in close proximity to the road network. This relationship will have significant impacts with respect to ambient air quality, and the effects of different vehicle and industrial emissions should be appropriately considered in town-planning and remediation exercises.

4.4.4 Sugarcane Burning

Commercial sugarcane cultivation forms a significant percentage of iLembe's land use (30.55 % compared with the total of 0.25 % for urban and industrialised land). During the winter harvest months, most sugarcane fields are burned in order to reduce harvest time and cost of labour (Seppings, 2005). When reconsidering the area of land used for commercial sugarcane cultivation identified in Figure 4.11, it is clear that there is a very large pollution potential associated with these burning activities.

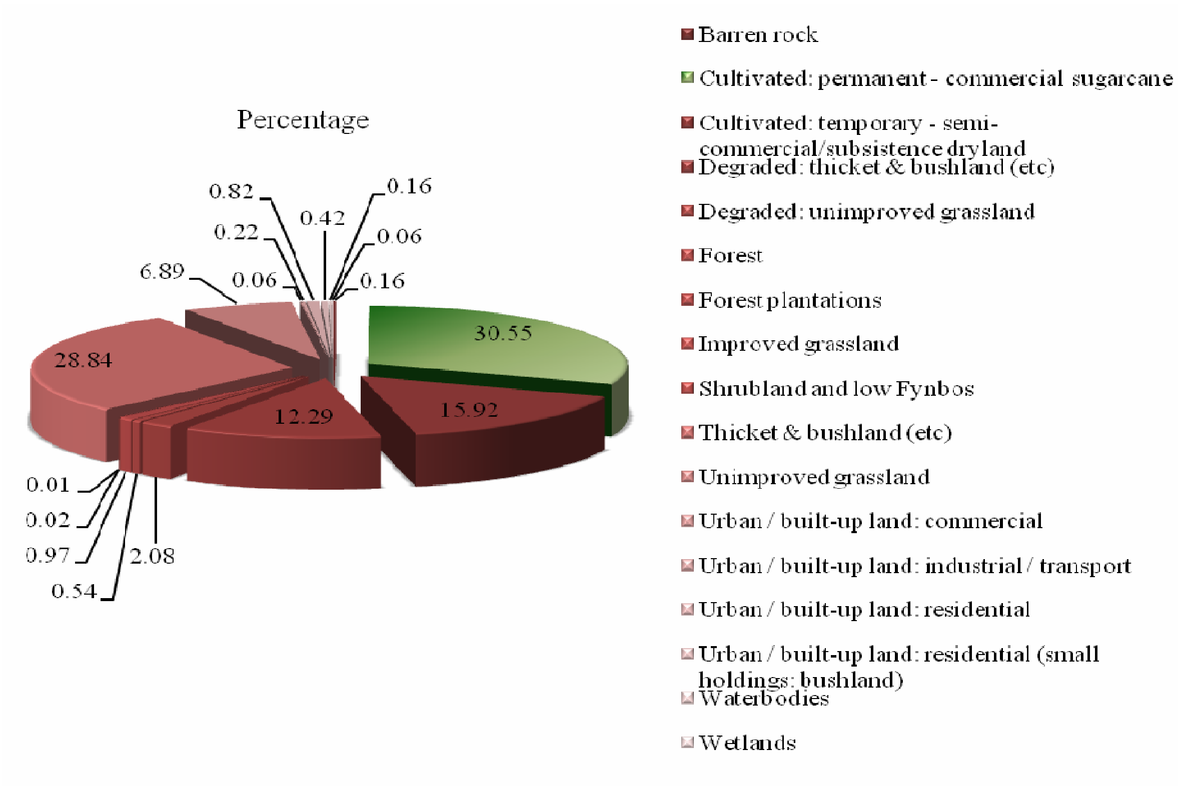

Figure 4.11: Pie chart showing proportionate land use in iLembe (source: iLembe GIS Database)

Such activities are prominent in the KwaDukuza region, where most of the local municipality is under commercial cultivation (Fig. 4.12). While the South African Sugar Research Institute (SASRI) has introduced location-specific burning codes of practice, where farmers in certain regions are required to burn their crop in a staggered sequence to minimise the impacts on surrounding communities (SASRI, 2007), it is clear that sugarcane burning is a significant source of pollution in the iLembe District.

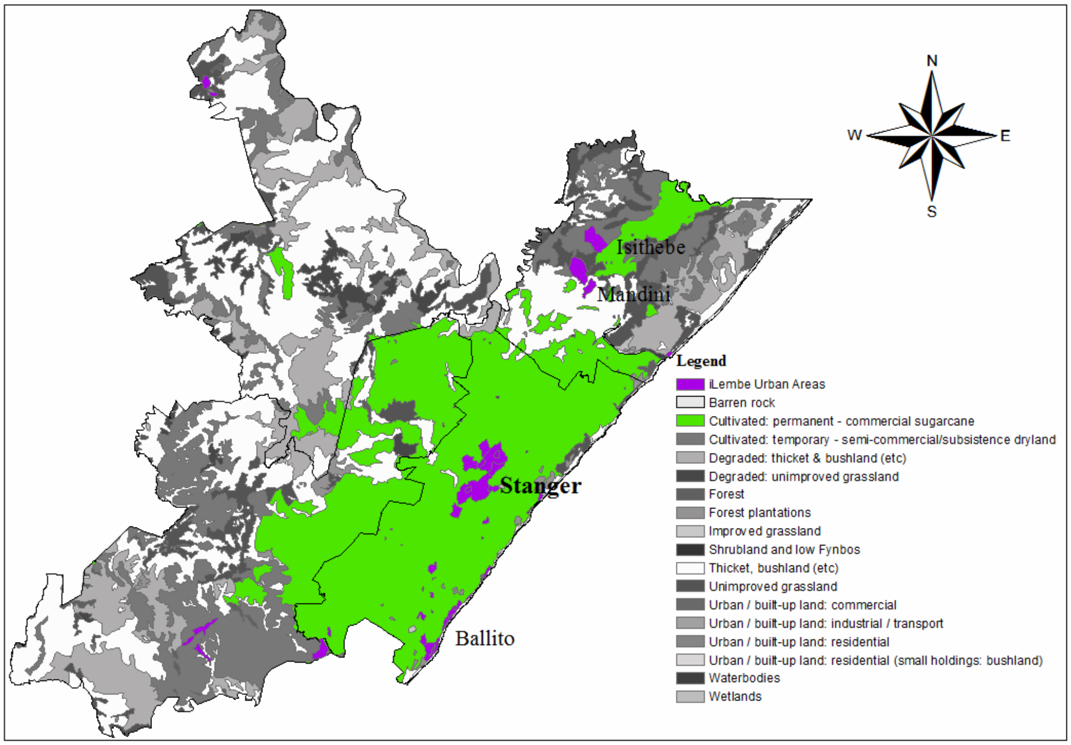

Figure 4.12: iLembe land use (source: iLembe GIS Database)

According to Seppings (2005:49), farmers burn their sugarcane prior to harvesting in order to reduce the extraneous leafy material, improve harvesting productivity (less foliage to cut and handle), and improve the quality of the sugar. Increasing harvesting productivity also lowers harvesting cost, saving money for both the farmer and the consumer. Approximately 90 percent of South African sugarcane farmers use manual labour to harvest their crop, thus an easier harvest results in a less labour-intensive exercise. Additionally, harvested crop with less foliage results in a higher proportion of usable product on hauliers and ultimately fewer vehicles on the roads, thus reducing vehicle-related emissions and road damage, as well as wear and tear on machinery at the sugar mills. It has also been proposed that crop burning increases soil productivity owing to increased micro-organism activity and nutrient recycling.

Seppings (2005) presents tabled data from a burning season in Hawaii in 1990, detailing individual pollutant emissions based on overall crop production. Table 4.5 shows this data with comparative South African sugarcane burning emissions for 2007 based on harvest predictions by the South African Sugar Association (SASA) (SASA, 2007a). The South African emissions predictions are approximations based on a proportionate total crop mass ratio of 1:3.25 to the Hawaii data.

Table 4.5: Annual emissions from sugarcane burning in Hawaii, 1990 (adapted from Seppings, 2005, Table 9.10 and SASA, 2007a) (all measurements in tons per annum)

Country	**Total Production**	**Dry Matter**	**Oxidised C**	**Released N**	**CH_4**	**N_2O**	**NO_X**	**CO**	**Total**
Hawaii	6 540 925	437 980	180 956	1 158	543	8.1	140	10 857	11 548
South Africa	21 223 000	1 423 435	588 107	3 763	1 764	26	455	35 285	37 531

According to SASA (2007b), Darnall and Gledhow sugar mills in iLembe together processed 2 421 250 tons of the 2006/2007 crop, which totalled 20 278 603 tons. Thus iLembe processed 11.4 percent of South Africa's sugarcane, and it is likely that this translates to a similar percentage for the amount of sugarcane grown. iLembe therefore represents a significant proportion of the country's sugarcane crop, supporting an important contribution towards the municipality's income through productivity and taxes.

Although sugarcane burning is possibly the single largest contributor to atmospheric pollution in the area owing to the extent to which it occurs, the contribution to individual pollutant concentrations varies considerably. Given that iLembe processed 11.4 percent of South African's 2006/2007 sugarcane crop, proportionate emissions calculations indicate that burning contributed 201.1 tons of CH_4, 2.964 tons of N_2O, 51.87 tons of NO_X, and 4 022.5 tons of CO during that season (Table 4.5).

These figures can be compared with the emission inventory supplied by Mjoli *et al* (2007) (Table 4.2), where SAPPI Mandeni and Gledhow Mill contribute larger amounts of NO_X (620.865 tons and 421 tons respectively), but lesser amounts of CO (2 978.4 tons and 143 tons respectively). The contribution of airborne particulates from sugarcane burning has not been accounted for in Seppings's study, but it is possible that this is the pollutant of greatest concern, given its impact on visibility as well as its nuisance effects (for example, ash accumulation on buildings, cars, laundry, etc.).

Provided that prevailing meteorology does not hamper fire management, the sugarcane burning schedule is usually dictated by the receiving sugar mill according to its processing capacity. Assuming suitable weather, the mill will allocate specific load capacities to the farmers, which then influences the burning in each associated area. Thus the mill is in a position of authority to determine the location of likely crop fires during particular periods. However, as certain conditions can prevent sufficient fire management, the development of ideal burning conditions may stimulate widespread opportunity harvesting (Lynski, 2007: pers. comm.).

Well-developed relationships exist between commercial and small-scale sugarcane farmers and many community groups, where farmers' associations may provide pre-burning warnings when they are able. Burning is also required to operate in accordance with industry practices, which in turn are governed by the National Veld and Forest Fire Act (No. 101 of 1998) and the National Forest and Fire Laws Amendment Act of 2001. Through this legislation, the National Fire Danger rating Index System (NFDRIS) was introduced, which is a tool designed to provide warning to farmers of dangerous burning conditions. However, aside from these tools, the sugarcane industry remains largely self-regulating (Lynski, 2007: pers. comm.). It is thus important for the iLembe environmental regulators to develop a close working relationship with the local sugarcane growers' associations and sugar mills.

4.4.5 Indoor Air Pollution

Widespread sources of indoor air pollution can act as significant area sources of air pollution, particularly where fossil fuels are inefficiently combusted. The amount of time that people spend indoors in both rural and urban areas also introduces significant chronic health risks associated with poor indoor air quality (Jacobson, 2002:242). Figure 4.13 indicates the types of fuel used for household lighting in the densely populous areas of Isithebe, Endlondlweni, Sundumbili, Shakaville, Stanger, and Groutville. Pollutants associated with fossil fuel combustion include CO, NO and NO_2, SO_2, and VOCs (including benzene, a human carcinogen) (Jacobson, 2002:243-247).

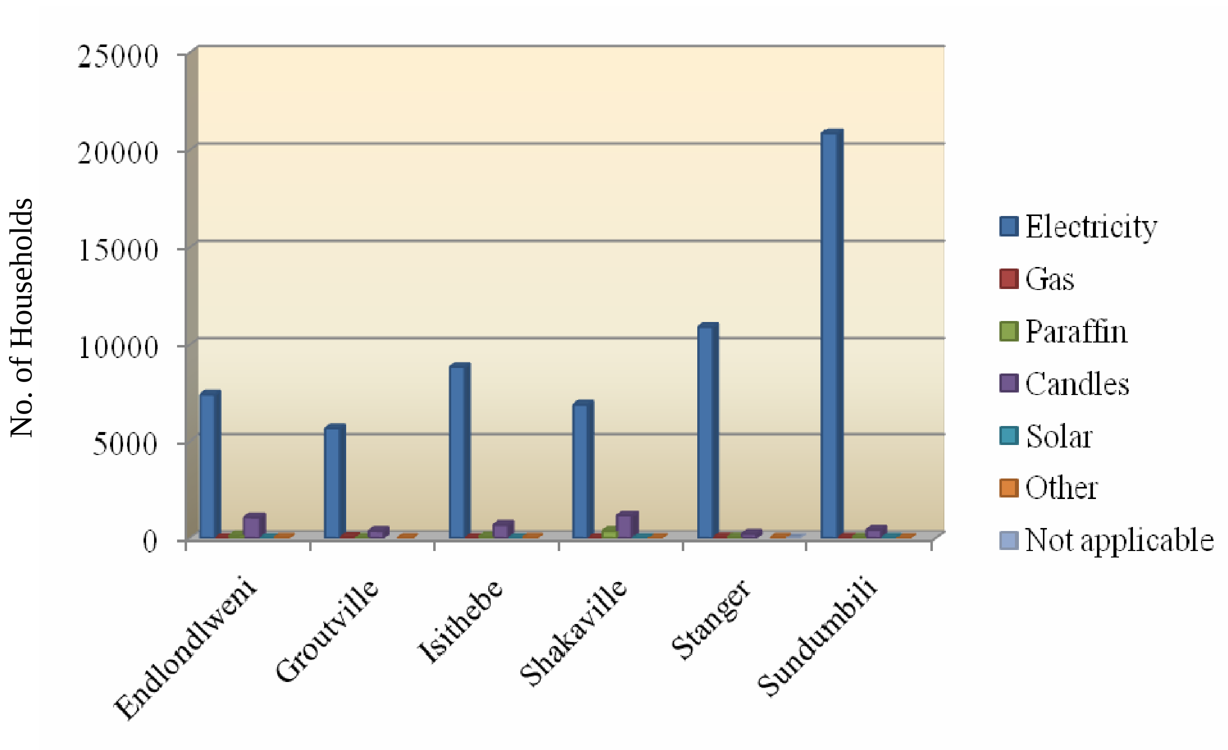

Figure 4.13: Bar graph showing household fuel sources for lighting (source: Statistics South Africa, 2001)

Although the occurrence of these pollutants in households requires regulation under the Occupational Health and Safety Act (Republic of South Africa, 1993), the mass generation of these emissions in communities can significantly reduce ambient air quality. Although electricity is the most widely used source of energy, its exclusion from analysis presents a clearer picture of the prevalence of more locally-polluting fuels (Fig. 4.14).

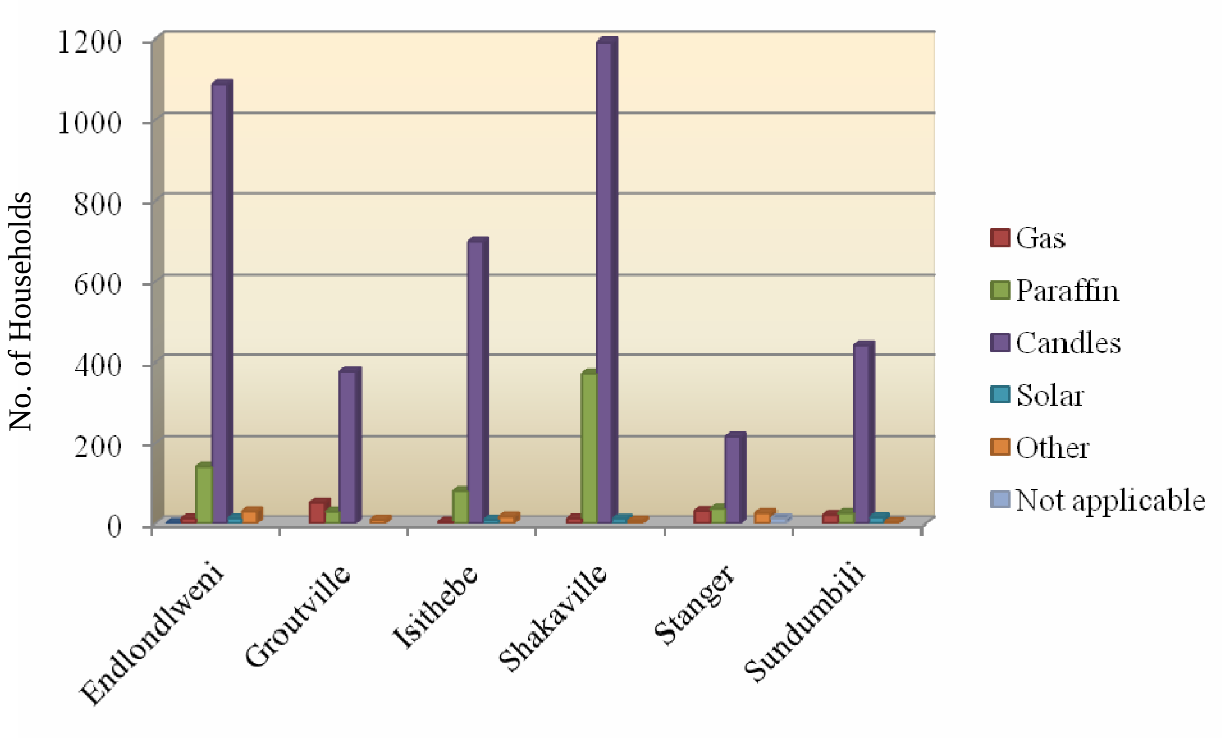

Figure 4.14: Bar graph showing household fuel sources for lighting excluding electricity (source: Statistics South Africa, 2001)

4.5 Ambient Air Quality Data

There is a single air quality monitoring station operating in iLembe. The station is located at Sundumbili Higher Primary School in Sundumbili Township near Mandeni. It was commissioned in 2005, and is equipped to capture rainfall, temperature, wind direction and speed as meteorological parameters, as well as SO_2, ozone, NO_X and PM_{10} concentrations. Problems encountered regarding the station's operation include a lack of technical expertise, uncalibrated equipment, computer malfunction, lack of accessibility to captured data, and malfunctioning equipment. As a result, very little data are available from this station (Sukhdeo, 2007: pers. comm.).

Hence, the only data that could be accessed for this research pertains to limited SO_2 data provided by Mjoli *et al.* (2007) for the months of January and February 2007. The data provided by Mjoli *et al.* (2007) indicates minimum, maximum, median and average values for all days that concentrations were measured, but there is no indication of data averaging periods. Figure 4.15 presents the daily average concentration values. The time series is sporadic, with measurements commencing on 8 January 2007, a data gap from 23 January to 3 February, and February measurements beginning on the fourth.

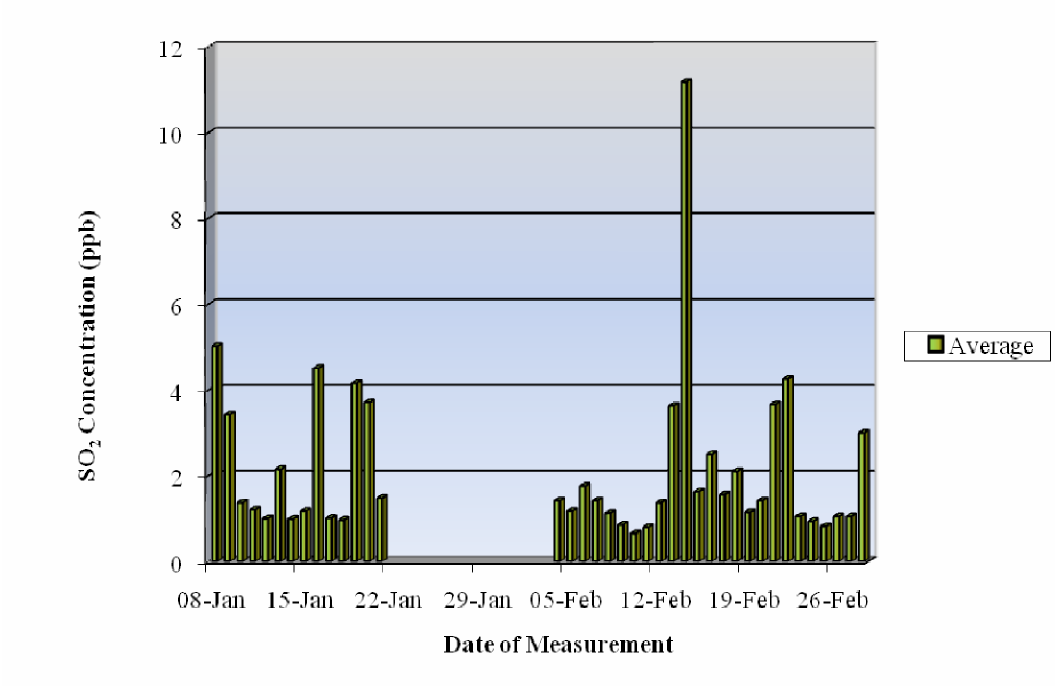

Figure 4.15: Bar graph showing measured SO_2 concentrations at Mandeni monitoring station for January and February 2007 (adapted from Mjoli *et al.*, 2007)

Comparison of the measured concentrations against the proposed 24-hour ambient standards (DEAT, 2007a), stated in Table 2.1 in Chapter 2 as 125 $\mu g.m^{-3}$ (or 48 ppb) indicates that there were no ambient SO_2 exceedances at the Mandeni monitoring station during the recorded days in January and February of 2007, with a highest recorded value of less than 12 ppb. However, given the substantial gaps in data, the short monitoring window, as well as uncertainties relating to averaging times and measurement accuracy (no information is provided pertaining to the instrument calibration dates, credibility of calibration specialists, etc.), these data should not be used as an indicator that ambient air quality is acceptable in iLembe. Table 24 of the National Framework indicates that iLembe has been identified as having potentially poor air quality (DEAT, 2007). Urgent intervention is required to obtain more reliable ambient air quality data if meaningful progress is to be made on the AQMP.

4.6 Current AQM Practices, Risk and Health Assessments

At present, air quality issues in the municipality are dealt with largely on an *ad hoc* basis, where complaints from residents in receptor areas may trigger communication between the authority and the offending industry or emitter (Sukhdeo, 2007: pers. comm.). Although intermittent fora are held with certain key emitters and interested stakeholders, the infrequency of these meetings and lack of general follow-up are clear. It was noted that the district's department of environmental health is unable to adequately address air quality issues owing to staff shortages and lack of appropriate skills. Existing staff do not have the institutional capacity to assume air quality management responsibilities, and the department has still to appoint an air quality control officer (Sukhdeo, 2007: pers. comm.). This is consistent with Naiker's (2007) study, which indicated that 28% of municipal environmental health departments planned to employ additional staff in order to meet AQM needs (Naiker, 2007: 101).

Aside from Seppings' (2005) study, discussed in Sections 4.4.2 and 4.4.4, no risk or health assessments have been undertaken for iLembe (Sukhdeo, 2007: pers. comm.).

4.7 Current and Future Trends in iLembe's Ambient Air Quality

The current trend in ambient air quality in iLembe indicates a likely deterioration, owing to the inability of the district's environmental health department to adequately address air quality issues. Development trends show an increasing number of residential housing estates planned for the coastal areas such as Ballito, Zinkwazi and Blythedale Beach (iLembe District Municipality, 2006: 53). Most of the land purchased for these estates has been acquired from Moreland, the property division of sugarcane-growers Tongaat-Hulett Group (iLembe District Municipality, 2006:53). An increased number of housing estates will result in a concurrent increase in road traffic and therefore vehicular emissions. Although the area of land dedicated to sugarcane growing may decrease in certain areas, the overall impact of sugarcane burning may not be lessened to a noticeable degree owing the distribution and number of sugarcane farmers in the district, as well as the effects of long-range pollution transportation. Developments in the industrial centre of Richards

Bay will also impact on transboundary pollution potential, both directly from industrial point sources, as well as through increased traffic flow through iLembe. The tourism industry is also currently expanding, which will further increase vehicle emissions in the district (iLembe District Municipality, 2006: 56).

The district's location between Durban harbour in eThekwini and the Port of Richards Bay in uThungulu, as well as the proximity of the King Shaka International Airport and associated Dube TradePort currently under construction in the north-east of eThekwini, increases the potential for iLembe to capitalise on spill-over investments (iLembe District Municipality, 2006: 56). For example, Isithebe has been earmarked for further industrial development in order to maximise trade opportunities created through the King Shaka airport and Dube TradePort (iLembe District Municipality, 2006: 56-57). However, a backlog in the provision of supporting infrastructure such as water, sanitation and electricity is likely to hamper this trend (iLembe District Municipality, 2006: 56). Recent decreases in the availability of electricity on a national scale will compound this effect. South Africa's energy supplier, Eskom, recently recommended that the country place a moratorium on all large industrial developments until at least 2013, when the electricity supply is expected to improve (Enslin-Payne and Brown, 2008).

However, these trends require further investigation and ratification through quantitative emissions data analysis and emissions forecasting. There is also an opportunity for the environmental health department to form a working relationship with the district's town planners, as present and future commercial and industrial developments (and residential developments to a lesser degree) will impact on localised ambient air quality.

4.8 Air Quality Issues

4.8.1 Receptor Areas

There are a number of locations in iLembe that are likely to be affected by poor air quality, depending on prevailing weather conditions, proximity to sources, volume, rate and types of emissions, stack height (where applicable), and pollution persistence. As most of these conditions may vary on a day-to-day basis, it is relevant to examine those areas likely to be regularly affected as per source type and prevailing wind directions.

The density of potential point-source emitters in the Mandeni/Isithebe area is likely to have the greatest impact on the eNdondakusuka communities of Isithebe, Endlondlweni, Sundumbili and Mandeni, as well as other adjacent but less-populous communities. Similarly, but to a lesser degree, certain areas of Ballito in KwaDukuza will be affected by the sand- and stone-extraction operations in the area, as will areas of Stanger. A number of rural communities in Maphumulo and Ndwedwe may be adversely affected by road-based emissions, and it is likely that urban communities in Stanger, Mandeni and Isithebe suffer from similar problems (Fig. 4.9 and 4.12).

The scale on which sugarcane burning occurs makes it the largest contributor to poor air quality in the region despite staggered burning operations governed by local mill schedules (Seppings, 2005). Over a burning season, and accounting for long-range particulate transportation, most of the district is likely to be affected at varying times. Populous communities of note in this regard include Stanger, which is located in the centre of the sugarcane belt, Darnall, Zinkwazi, Mandini, Isithebe, Sundumbili, Endlondlweni, Ballito, Ndwedwe, Shangase Village, and Hlomantethe, all of which lie along the northeast-southwest wind axis. uThungulu and eThekwini municipalities will also be affected by sugarcane burning, given that they are situated to the north-east and south-west respectively. This highlights the need for inter-municipal co-operative governance initiatives, where representatives from each municipality may hold positions on neighbouring air quality steering committees (Section 3.6.2).

A number of sensitive natural environments are noted, significantly including wildlife reserves, wetlands, other sensitive habitats, breeding sites, and estuarine systems (Fig. 4.16). Such areas will need to be accounted for when assessing the impacts of poor air quality, particularly those areas situated within the sugarcane belt as they are not only likely to suffer combustion-related impacts, but will also be under threat of fire.

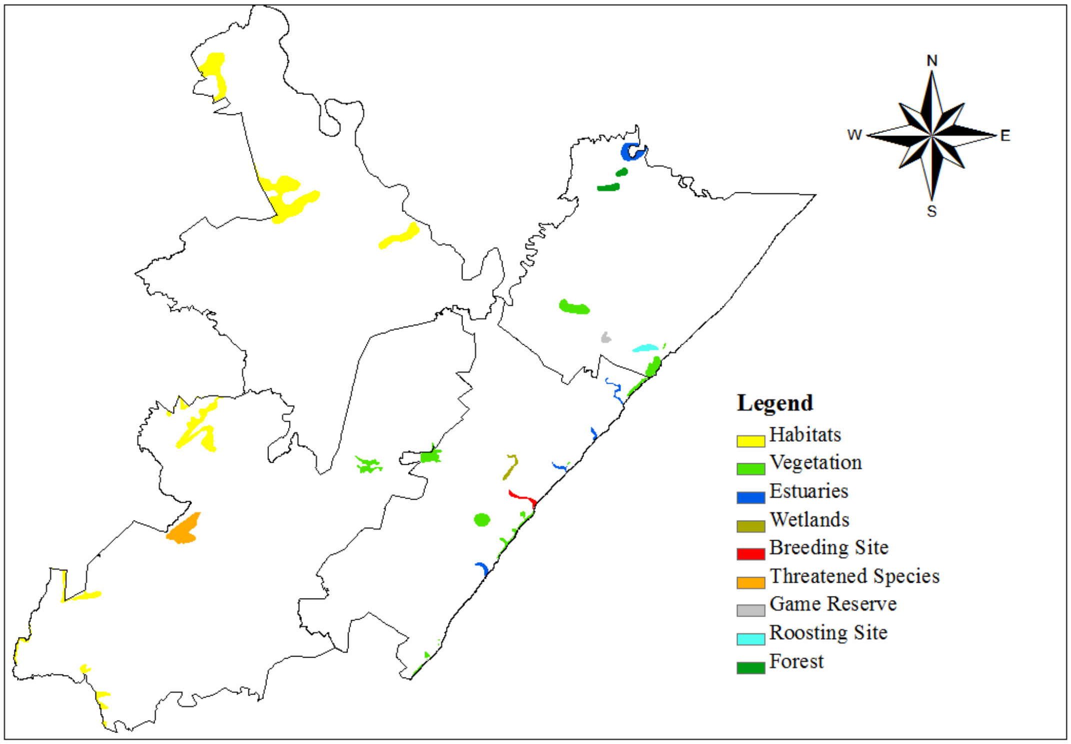

Figure 4.16: Sensitive natural environments (source: iLembe GIS Database)

4.8.2 Transboundary Pollution

There are a number of factors that may result in medium- and long-range transport of pollutants to areas adjacent to industrialised, urban, and sugarcane areas, as well as those areas adjacent to the municipality. Generally, industrial clusters will emit larger quantities of pollution than single point sources, thus areas adjacent to such clusters are likely to be more affected by air quality-related health and nuisance impacts than those areas adjacent to single, isolated sources. Similarly, receptor areas located along the prevailing wind axis on either side of such clusters will be susceptible to poor air quality episodes. This is particularly relevant to communities to the north-east of Mandeni and Isithebe in uThungulu Municipality, and those communities to the south-west of Ballito in eThekwini, as they will be affected by, as well as affect, the air quality in the respective locations.

Mountain-valley winds and prefrontal conditions in the interior of the district may result in certain areas of Maphumulo and Ndwedwe being affected by pollution from uMzinyathi and uMgungundlovu District Municipalities, although this will depend on industrial, urban and agricultural activities in these locations. The burning of grassland firebreaks in the interior of the province is a common method of controlling the potential outbreak of wild fires, and these activities may impact on the aforementioned sensitive environments, as per prevailing meteorology. Topography is likely to play a greater role in these areas, both in terms of shielding communities from upwind pollution as well as creating pollution accumulation in other locations.

Regional mountain-plain winds, which develop during the night between the Drakensberg mountains and the coastline (Preston-Whyte, 1974), may transport air pollution generated inland of iLembe in uMzinyathi and uMgungundlovu Municipalities over the district and out to sea. However, the development of onshore circulations during the day, as well as north-easterly winds induced by synoptic-scale pressure systems, may return any transported pollution back to the coast. Thus, pollution emitted in uThungulu municipality is likely to affect iLembe during such conditions, as will pollution emitted in iLembe be likely to affect eThekwini, as north-easterly winds will transport offshore pollution towards the south-west.

The scale at which sugarcane burning occurs increases the significance of long-range pollution transport, particularly concerning particulates and ash which are light enough to be borne long distances by the wind. If burning is assumed to occur most frequently following the passage of a temperate cyclone, given that the cooler, breezier conditions are more conducive to fire control than prefrontal conditions characterised by hot, dry weather, then the long-range transport of pollutants will impact on the neighbouring uThungulu District Municipality (Fig.4.2 and 4.12). However, weather conditions during an established continental high-pressure system (north-easterly winds) may result in eThekwini municipality being affected more apparently than uThungulu given the extension of the sugar belt to the south-western border of iLembe (Fig. 4.12). These impacts may extend in return to iLembe, where crop burning in north-eastern eThekwini and south-western uThungulu will affect communities and environments that lie along the prevailing wind axis.

Both uThungulu and eThekwini municipalities are classified by the National Framework as having 'poor' air quality (DEAT, 2007a, Table 24). Additionally, areas of iLembe may be affected by episodes of poor air quality in uMgungundlovu and uMzinyathi district municipalities, particularly during pre-frontal conditions when north-westerly winds prevail. This further highlights the need for inter-municipal co-operative governance initiatives.

4.8.3 Climate Change

Climate change, and the contribution thereto from the various pollution sources in iLembe, is an aspect of pollution management that extends beyond municipal borders. As such, it is unlikely to be a high priority for municipal air quality managers when there may be other, seemingly more important local impacts requiring remediation and management. However, the effects that climate change will have on the region, as well as the impacts that atmospheric pollution from the region have on climate change, remain largely unknown. Preventative interventions should be instituted where negative impacts are anticipated or possible. In the case of climate change, and aside from international obligations, this requires that mitigation measures be implemented in order to reduce the emission of GHGs, as well as to plan for the forecasted impacts of local climate change in the medium- to long-term.

As such, remedial focus should be applied to the GHGs already identified as emissions from certain industries (Tables 4.3 and 4.4), even if they have not yet been ascribed ambient standards in the legislation. Examples of such GHGs include CH_4 and N_2O, both of which are recognised as important long-lived GHGs by the Intergovernmental Panel on Climate Change (IPCC) (Solomon *et al*, 2007). Both of these substances have been noted as emissions from sugarcane burning (Table 4.5). Other GHGs noted in Tables 4.3 and 4.4 include the persistent organo-halogens from the iron foundry, possible fluorine compounds and ozone from the chemical industry, CO and CO_2 from most processes (likely due to the use of boilers), and SO_2 and NO_X which are largely associated with vehicles and the sugar and paper industries (Solomon *et al*, 2007). Public meetings held in areas of concern, as well as further investigation into smaller industries, may reveal additional GHG emissions from other sources, which in turn will require detailed assessment for the application of reduction and control measures where applicable.

Sugarcane burning contributes towards climate change in two ways, both of which relate to the crop harvest. Although not a significant impact in itself aside from emissions from harvesting vehicles, the annual harvest results in the removal of large vegetated areas of land (30.55 % of iLembe - Fig. 4.14), which throughout the year sequester compounds of atmospheric carbon through photosynthesis (i.e. they act as carbon sinks). When the sugarcane is removed, the land can no longer perform this function, thus having an impact on climate change through vegetation depletion.

The second impact is more direct, and occurs as a result of crop burning. Emissions from sugarcane burning include CH_4, N_2O, NO_X, CO and CO_2 (see Table 4.5), all of which are GHGs (Solomon *et al.*, 2007). Although many of these pollutants are emitted by industries as well, the scale on which crop burning takes place makes it a significant source of GHG emissions, and hence possibly a larger contributor to climate change in some instances.

4.9 Data Limitations

Various problems with data and their availability must be noted. All maps produced in this chapter have not been projected owing to significantly poor map data integrity obtained from the municipal database. Although this has impacted upon data quality, there is sufficient documentary evidence through DEAT (Scott, 2007: pers. comm.) or the 2001 Census (Statistics South Africa, 2001) to support the data represented in these figures. It is recommended that a common, appropriately-georeferenced database be developed for all future studies in order to ensure data quality consistency.

The spatial resolution of the data stored in iLembe's GIS database varied considerably, and was generally not sufficiently detailed. For example, the location of potential anthropogenic emitters lacked contact and location addresses, making recommended follow-up ground-truthing exercises more difficult in terms of locating and confirming individual polluters. Differences between the national registration certificate database, the database developed by Seppings, and the municipality's own information further highlighted this. Data of a higher resolution may be available from local and international remote sensing agencies, and should be investigated further.

The scarcity of monitoring information from the station in Mandeni, the limited provincial emissions inventory data supplied by Mjoli *et al.* (2007), and the absence of industry-specific emission inventories further detracted from assessing baseline air quality, thus hampering the progression of the AQMP's roll-out. More comprehensive ambient monitoring data than those observed (Section 4.4.1) are available through the DAEA and DEAT (Piketh, 2007: pers. comm.). These data are currently undergoing review by provincial authorities and were not released for use in this study. It is strongly recommended that these data be obtained and confirmed against the results of this study prior to undertaking monitoring and modelling exercises.

CHAPTER 5
CONCLUSION

5.1 Summary

The management of air quality in South Africa has shifted from a system of source control under the APPA to a more holistic governance of ambient or environmental atmospheric pollution concentrations. This is as a result of the promulgation and ongoing implementation of the NEMA, the NEM:AQA and the National Framework. The framing of AQMPs within the broader municipal and provincial IDP system introduces a relationship between air quality management and other environmental and non-environmental management systems, which allows for the incorporation of air quality concerns into many other spheres of local and provincial governance. This decentralised governance system of municipal and provincial AQMPs has increased the degree to which local municipalities are able to investigate, manage, mitigate, and control atmospheric polluters and pollution, but the lack of resources and skills presents numerous challenges in terms of legislation, policy, and AQMP roll-out.

As such, a need for an AQMP development framework specifically designed for district-level municipalities was identified. A review of both national and international literature in Chapters 2 and 3 enabled the development of such a framework at the end of Chapter 3, where framework examples from the United Kingdom and location-specific examples from three metropolitan municipalities in South Africa were used in the development process. The final framework is essentially comprised of two sections: a two-stage baseline assessment, which involves the generation of an emissions inventory, public participation, and ambient atmospheric monitoring and modelling; and an AQMP system, including management and mitigation measures designed to maintain ambient air pollution at concentrations safe to human and environmental health, and a transparent, meaningful system of reviewing and reporting on the progress of the entire air quality management system, the continued improvement of which is of high importance.

Stage one of the AQMP framework's baseline assessment was undertaken in Chapter 4, where various aspects of iLembe District Municipality that affect, or are affected by, ambient air quality were objectively analysed. Such aspects included regional topography and climate, population distribution and density, the location of potential atmospheric emitters and the types of pollutants associated with a number of industrial activities, the location, number and type of scheduled processes (or listed activities) operating in the municipality, the effects of transboundary pollution on iLembe's neighbouring areas and possible return effects, and the impact of iLembe's emissions on climate change.

Discussion of these data indicated a number of receptor areas that are likely to require further investigation and monitoring, notably, in accordance with the framework's system of prioritising areas of dense human populations over less-dense communities, the areas around Isithebe, Sundumbili, Mandeni, and Stanger. It has been recommended that public meetings and ambient monitoring be undertaken for all of these areas, with a view to developing a comprehensive management strategy for each area under the guidance of the air quality steering committee, which has yet to be established by the municipality.

It is envisaged that the remainder of the AMQP implementation process will adhere to the framework developed in this study, with any structural changes thereto applied as appropriate to the situation in iLembe. Naiker's (2007) study observed the general lack of resources and capacity in local governments to adopt air quality management practices, and this has the potential to negatively impact upon the continued progress of pollution control in iLembe and other municipalities. Therefore, the need for capacity-building initiatives was recognised as being of great importance to the success of air quality management in the municipality, although initial use of third-party resources is anticipated and expected.

The important role of municipalities in bringing to effect the aims and objectives of international, national, provincial and local air quality standards has been highlighted throughout this study. In recognition of this, an effective framework for the adoption of air quality management systems has been created for use by district municipalities, the early stages of which have been successfully applied to iLembe. It is anticipated that the comprehensive application of this framework, along with sound scientific principles of investigation and analysis, will realise the achievement of ambient pollution concentration standards in each municipality in an effective, resource-efficient manner, ultimately attaining Constitutionally-acceptable atmospheric environments throughout South Africa.

It is also anticipated that the adoption of the framework developed in this research will aid in the development and implementation of AQMPs in South African district municipalities, largely by reducing the time and resource demands required for effective air quality assessment. By reducing the review and assessment process to a two-stage problem identification procedure in the baseline assessment, air quality managers will be able to identify those areas requiring management and mitigation measures, as well as other areas which are within acceptable ambient concentration limits. Additionally, by increasing the depth of the Stage 1 assessment and combining the monitoring and modelling processes of Stage 2, the overall time spent undertaking data accumulation can be significantly reduced, hence adding a further benefit to the overall process.

Finally, it should be observed that the development of a generic framework itself is a contribution towards the implementation of the NEM:AQA, as such a framework did not previously exist beyond the broader AQMP guidelines stipulated in the National Framework. Although much of the framework of Chapter 3 has been sourced from the UK guidelines, it provides a succinct yet inclusive methodology for the assessment of ambient atmospheric pollution, and the management measures (if any) required to ensure legal compliance.

5.2 Recommendations

Review of the preceding chapters indicates a number of areas of investigation and analysis that may require further study, or may need to be verified in some form. There are also aspects of the remainder of the AQMP development and implementation process that have been impacted upon by this study’s findings, and as a result may need to be altered. This section proposes recommendations which account for these changes and have been made to improve iLembe's AQMP roll-out.

Firstly, discussions on meteorology and topography indicated that the spatial resolution of existing images and data was insufficient to assess individual communities, but rather allowing a broad assessment of the district as a whole. As it has been indicated that both of these factors influence air quality and pollution dispersion to various degrees, it is important that further study be undertaken in this regard for noted receptor areas. Particular areas of concern include: Stanger, which may be subjected to surface temperature inversions due to its location in a low-lying area; Mandeni, Isithebe and Sundumbili due to the number of polluting industries in those locations and the density of people living adjacent; and Ndwedwe town which, although not characterised by a large number of emitters, lies juxtaposed between the coastal and inland belts, and this may create adverse ambient atmospheric conditions.

Secondly, detailed study is required on the potential emitters identified in this study, the focus of which should be the location of each source, the types, quantities and rates of emission of each pollutant generated by separate processes at each location, and the designation of requirement for AELs where applicable. These data are crucial for the effective monitoring of ambient pollutant concentrations in that they will form the basis of any remediation interventions introduced by the air quality steering committee. Moreover, sound scientific studies are based on the collection, analysis and understanding of accurate data, and thus the integrity of the AQMP depends significantly on the scope of this exercise. In accordance with Figure 3.4 and principles of good governance stipulated in NEMA and the Constitution (see Chapter 2), these studies must include public meetings, particularly in the identified industrial and densely populated areas of Isithebe, Sundumbili, Mandeni, and Stanger, in order to ascertain any additional pollutants of concern to the surrounding communities.

With respect to types of polluters, it is noted that although some statistics on indoor air pollution are presented in this study (Figs. 4.13 and 4.14), the use of these data is limited, as statistics on fuels utilised for cooking have been excluded. As previously mentioned, it is likely that there is more widespread use of polluting fuels in cooking than for lighting, but this requires further investigation as does the impact of the combustion of these fuels on ambient air quality. The effects of indoor air pollution are likely to compound any existing ambient pollutant exceedances, especially in the context of long-term exposure where poor ventilation may result in the inhalation of pollution on a 24-hour basis. (Such an investigation is required by Section 16 (a)(iv) of the NEM:AQA.)

In the same context, it is recommended that further studies be undertaken on the composition of the vehicle fleet, particularly in urbanised areas such as Stanger and Mandeni/Isithebe, as the volume and type of traffic may have a significant impact on local ambient pollutant concentrations. It may also be relevant for similar studies to be undertaken in the rural areas of Endlondlweni, Shakaville, and Groutville, where densely populated communities may be subjected to emissions generated by vehicles and road surfaces. Similarly, further research into the impacts of sugarcane burning in the region should be undertaken, following which discussions with local sugarcane growers, sugar mills, and sugarcane associations (such as SASA and SASRI) should initiate in order to improve the management of burning practices in terms of their effects on human and environmental health.

The monitoring exercises of stage 2 of the baseline assessment will involve the measuring of ambient pollutant concentrations and their effects on surrounding communities, both those located in the immediate vicinity of pollution sources, and those affected by the long-range transportation of pollutants. The framework developed in this research requires that dense human populations be accorded higher priority than less dense areas, followed in turn by the natural environment. However, areas of lower priority are not to be excluded, but dealt with in sequence when applicable resources are available. Both NEMA and the Constitution require that the natural environment be protected. This will involve further study of natural, sensitive receptor areas, where the information supplied in Figure 4.16 has been too generalised.

Beyond the remainder of the baseline assessment, there are a number of developments which the AQMP should take into account. For example, awareness of the pending development of the SAAQIS should be accounted for when developing and/or implementing any software packages for the air quality data management system, where provincial or national air quality officials should be consulted prior to doing so. GIS is internationally acknowledged as being an effective tool for storing, organising, viewing and presenting data, and is strongly recommended for use in the municipal air quality data management system as well. It is assumed that, as the SAAQIS is expected to be a GIS-based database (Section 2.4), the uploading of data from individual municipalities will be required to be compatible with the data formats used in the national database. Thus it follows that the use of GIS in the municipalities will simplify the introduction of data management systems during the implementation phase of the SAAQIS.

The air quality steering committee must ensure that it remains aware of any changes to national ambient standards as proposed by the National Framework, as this will have bearing on remediation and management interventions. Furthermore, the steering committee should also be aware of its ability to implement more stringent local standards in accordance with Section 10 of the NEM:AQA (see Chapter 2, Section 2.5). Mitigation and management interventions should be discussed by the steering committee, but should also consult examples from international literature (such as the DEFRA documentation discussed in Chapter 3) as well as ideas already used in other South African municipalities.

Capacity-building initiatives should be given high priority in order to increase municipal capability. This is essential for the continued success of the AQMP system, where a sound scientific base lends integrity to mitigation, management and control efforts. The development of skills within municipal departments should be given high priority, as the reliance on third-party (i.e. private sector) expertise is typically far more costly than the employment of in-house resources. In consideration of this, and given the need to ensure a comprehensive and effective AQMP, the information contained in this study as well as the outcome of the pending monitoring studies should be used to develop local AQMPs for the four local municipalities (eNdondakusuka, KwaDukuza, Ndwedwe and Maphumulo). Although these municipalities may not currently have the capacity to manage their own AQMPs, location-specific plans will encourage a more responsible approach to air quality management, given that each area will have aims, objectives, and target dates, and will encourage the development of local skills.

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APPENDIX

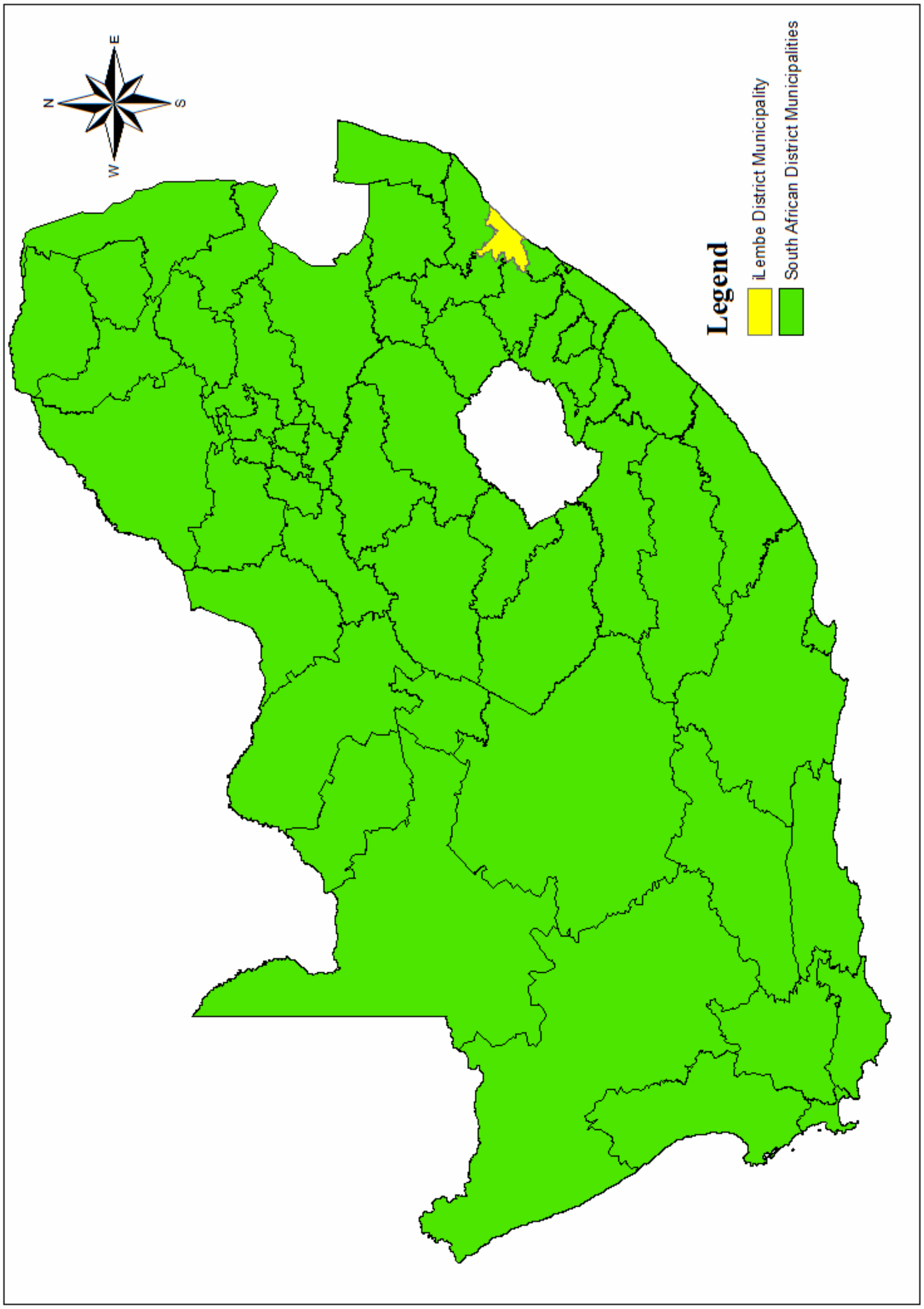

Figure 4.1: Map showing location of iLembe District Municipality in South Africa (source: Statistics South Africa, 2001)

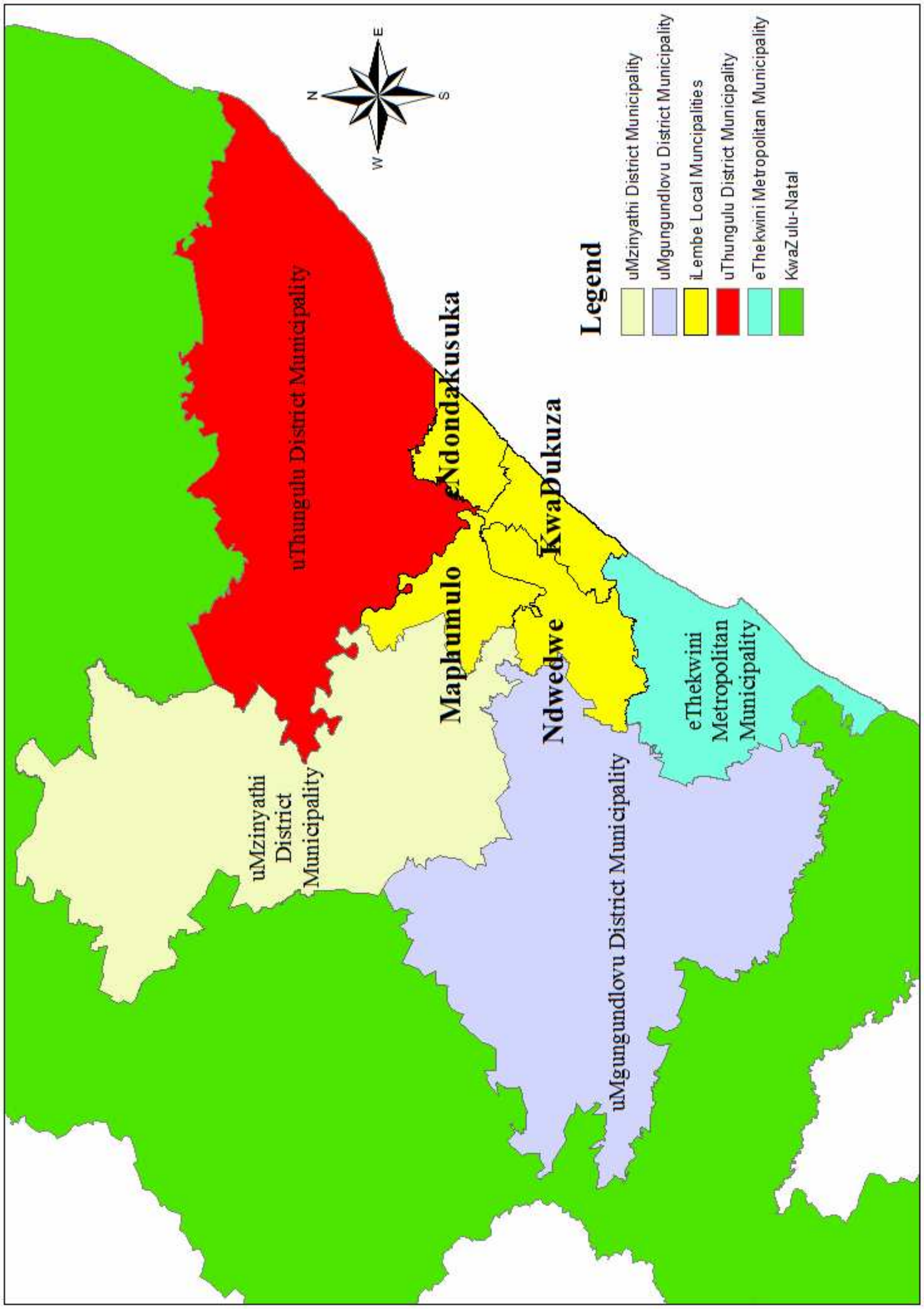

Figure 4.2: Map showing iLembe local municipalities and neighbouring district municipalities (source: Statistics South Africa, 2001)

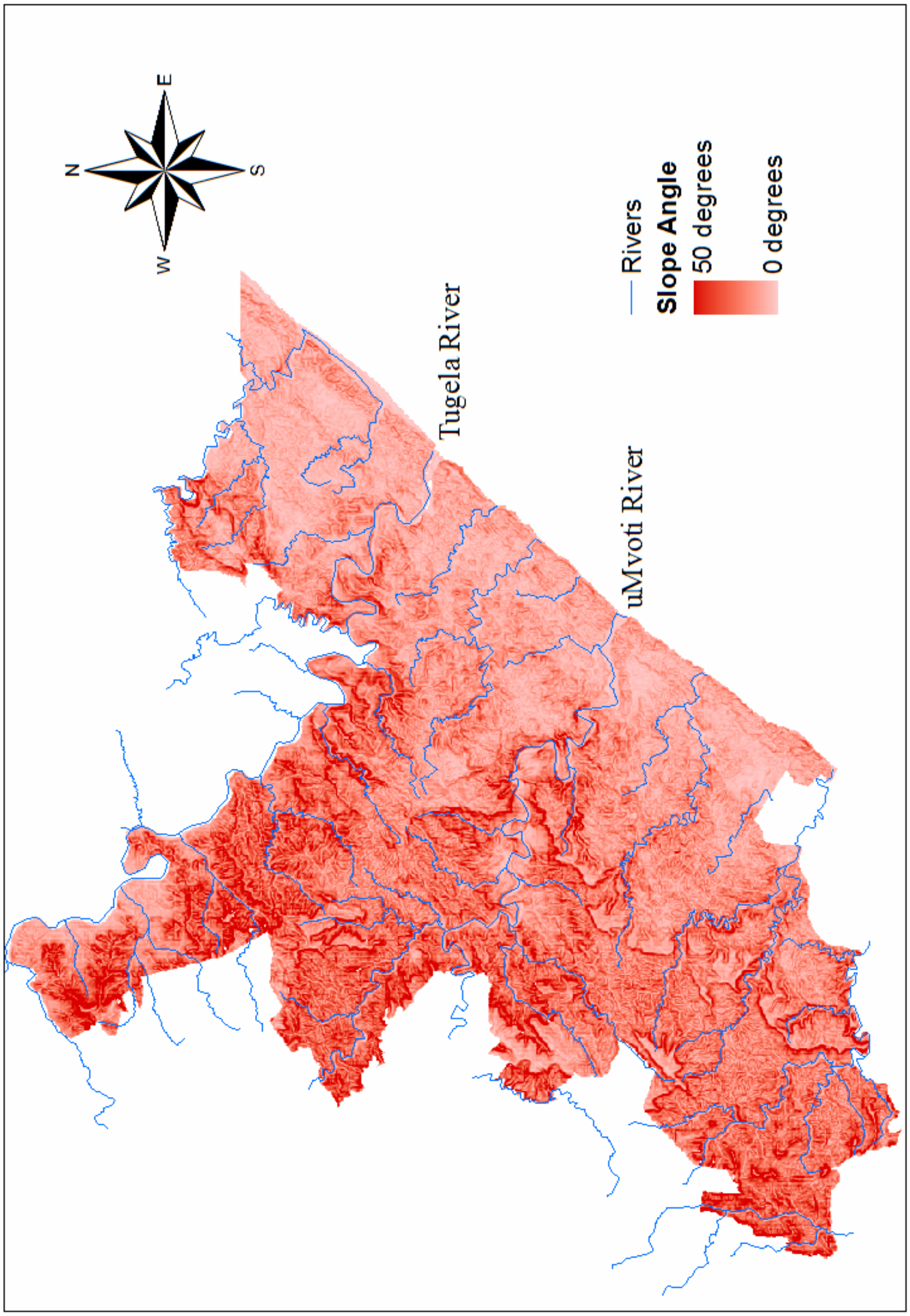

Figure 4.3: Slope analysis of iLembe with river systems (source: iLembe GIS Database)

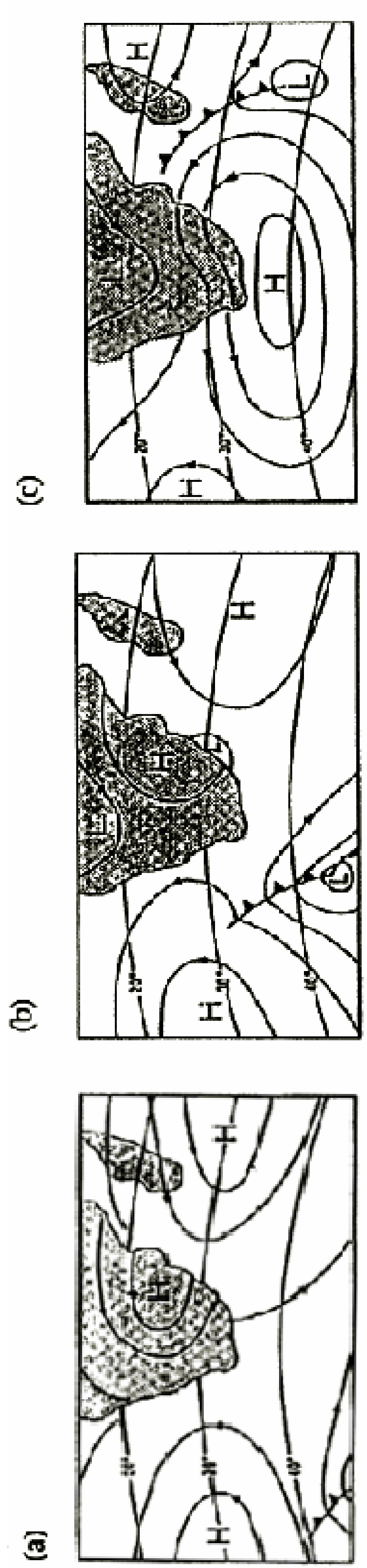

Figure 4.4: Synoptic sequence of APP conditions over South Africa (adapted from Scott and Diab, 2000)

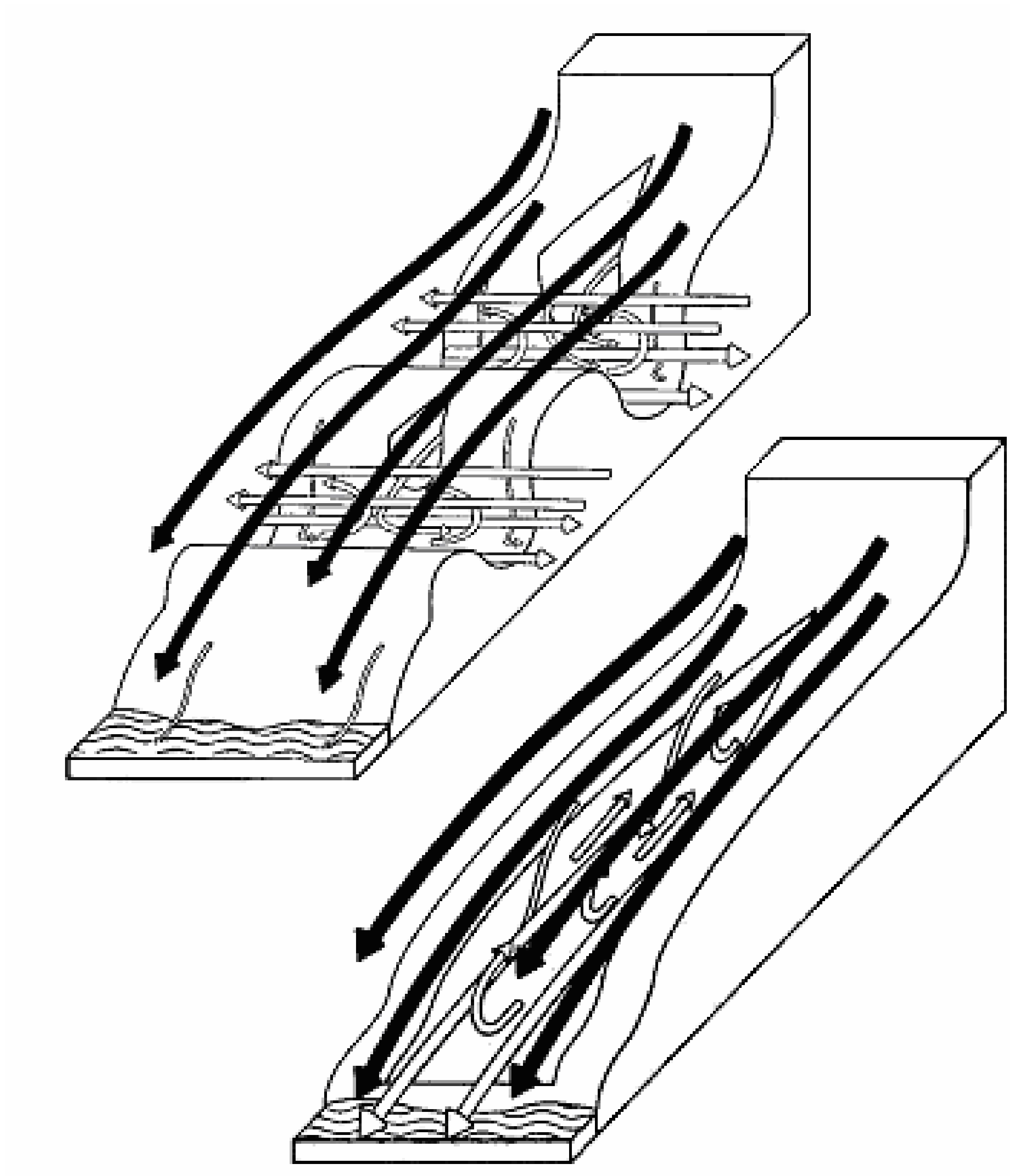

Figure 4.5: Diagram of Land Breezes in iLembe with Parallel Valleys at Right Angles to the Slope (top) and Valleys Parallel to the Slope (bottom) (Tyson and Preston-Whyte, 1972:644)

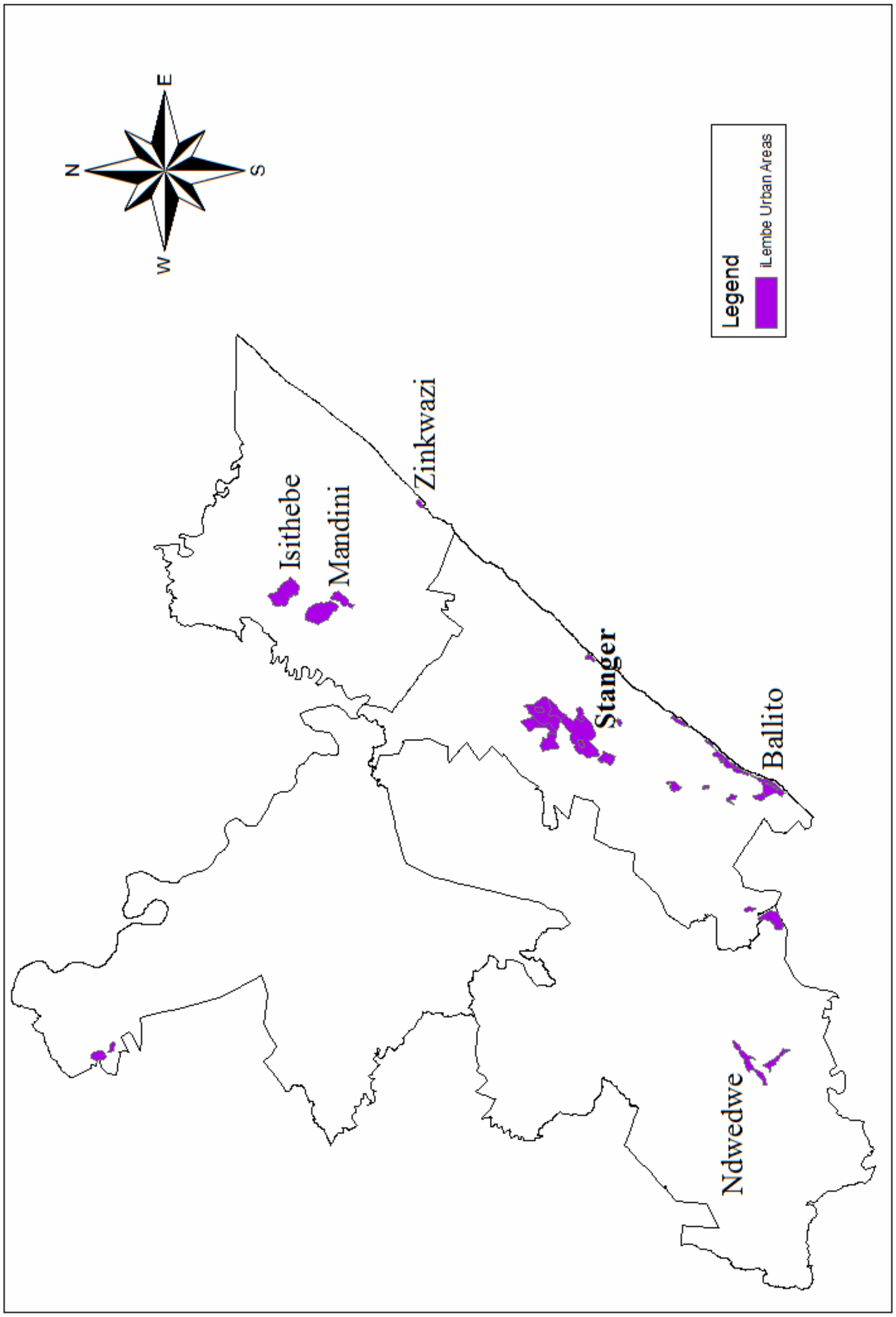

Figure 4.5: iLembe urban centres (source: iLembe GIS Database)

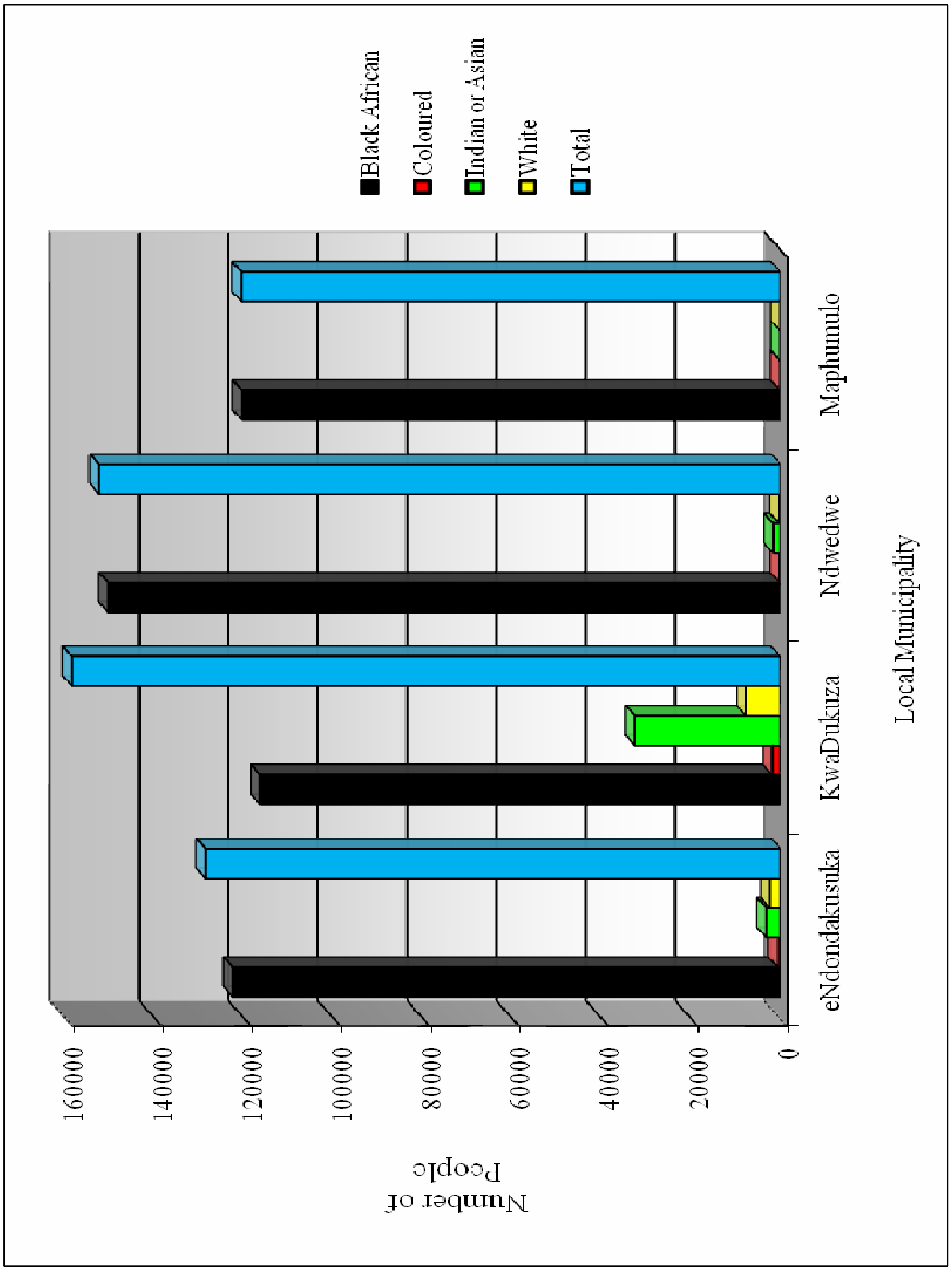

Figure 4.7: Bar graph showing population distribution by race and local municipality in iLembe (source: Statistics South Africa, 2001)

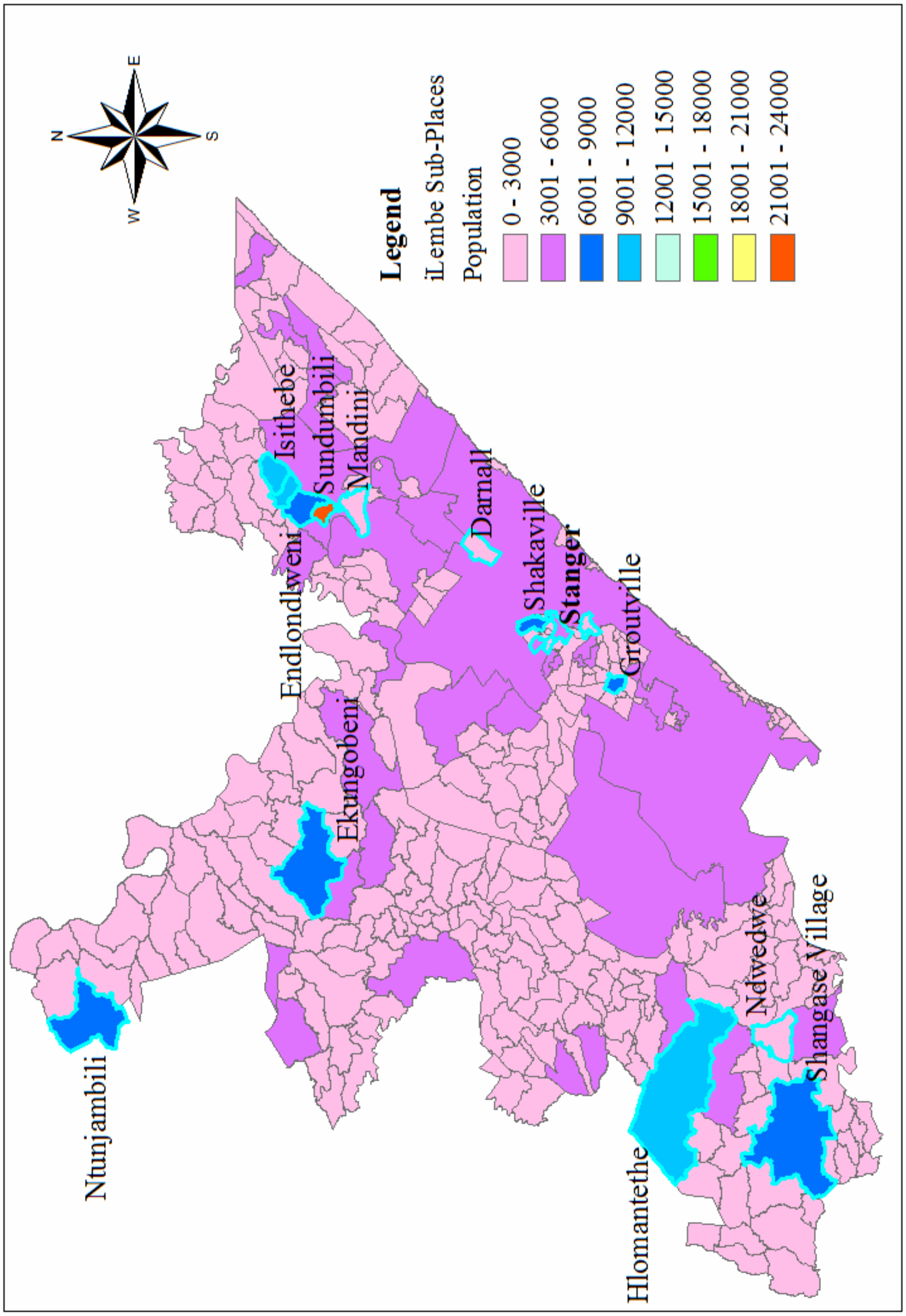

Figure 4.8: iLembe sub-place populations (source: iLembe GIS Database)

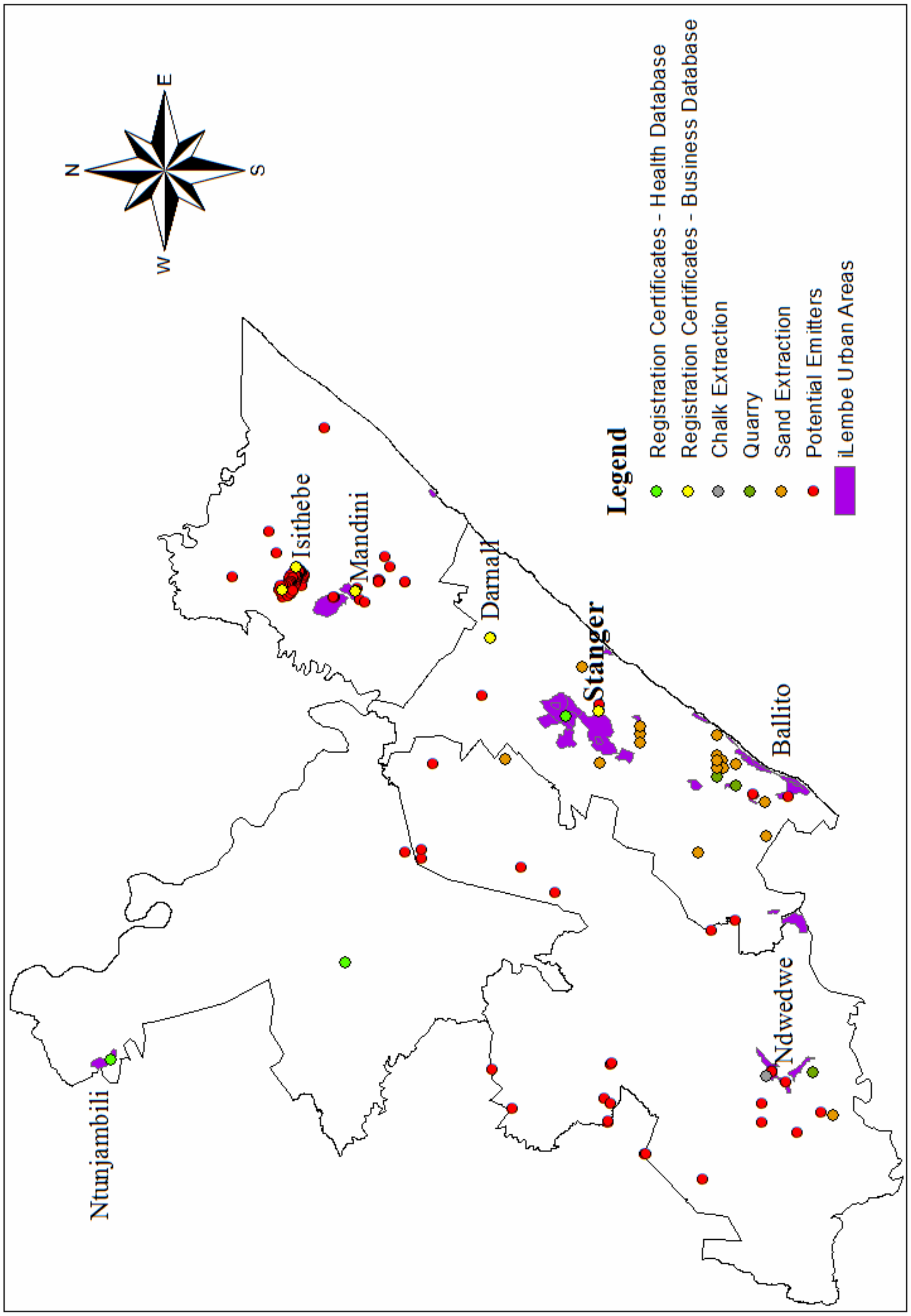

Figure 4.9: Location of potential anthropogenic point source emitters (source: iLembe GIS Database)

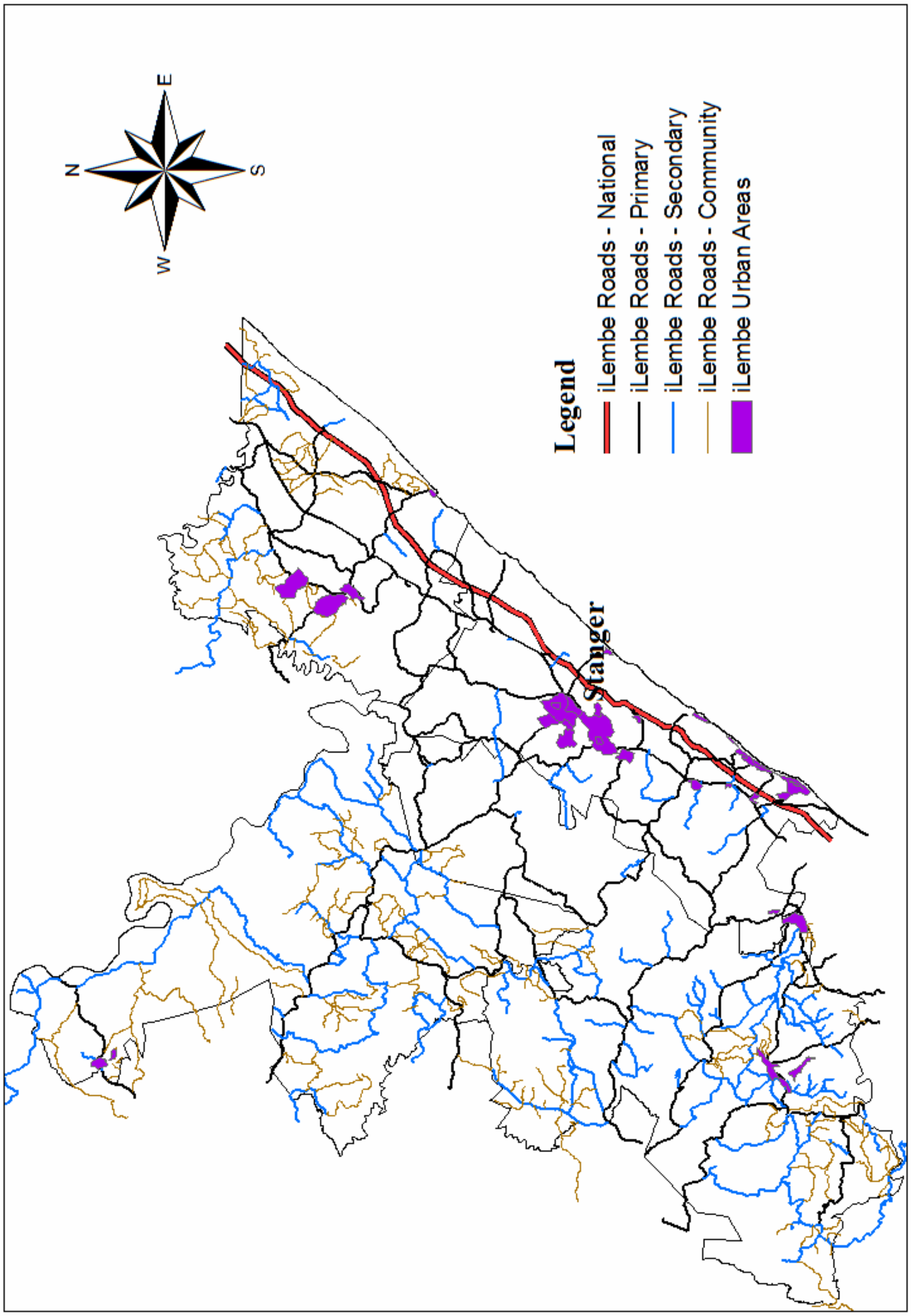

Figure 4.10: iLembe road network (source: iLembe GIS Database)

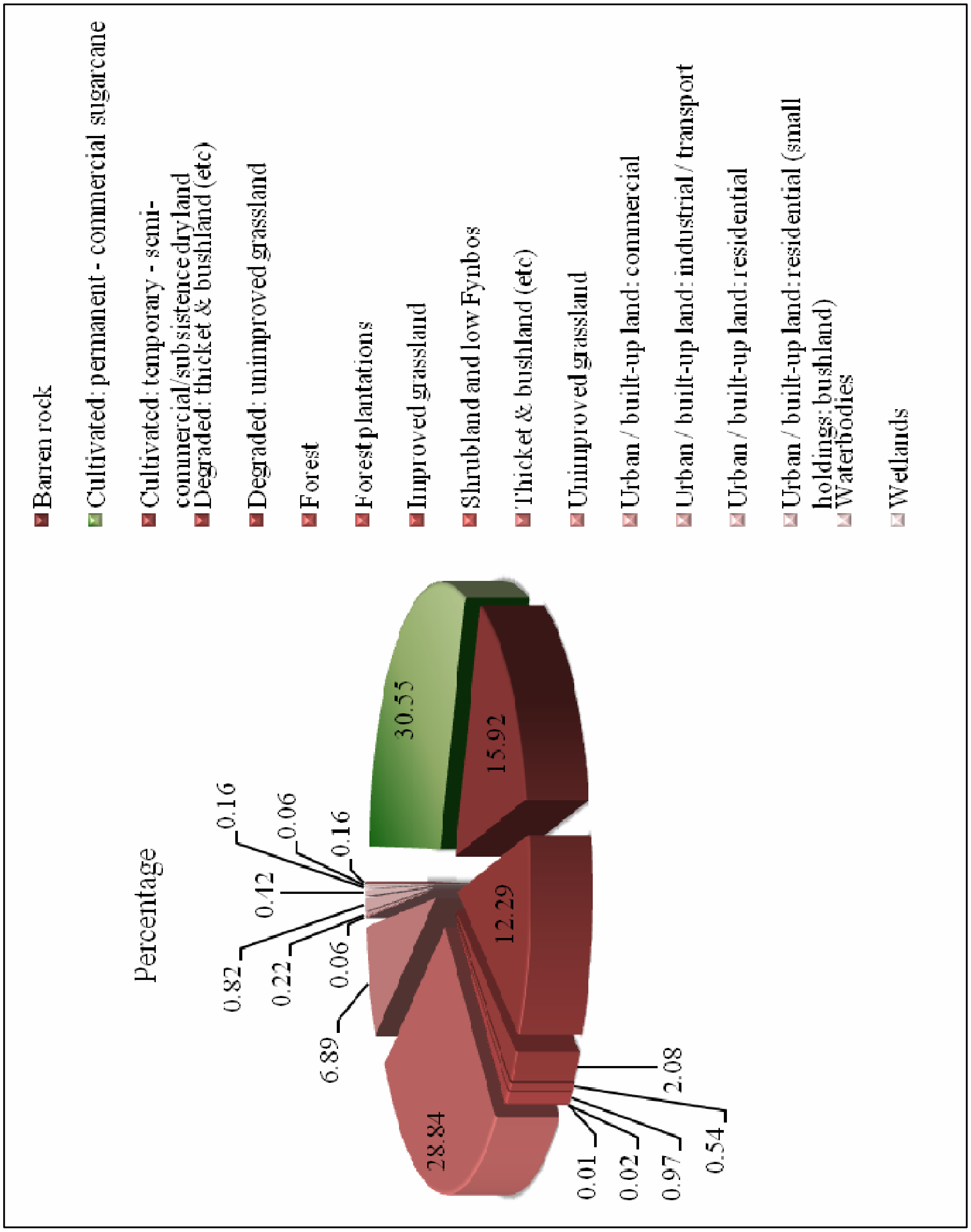

Figure 4.11: Pie chart showing proportionate land use in iLembe (source: iLembe GIS Database)

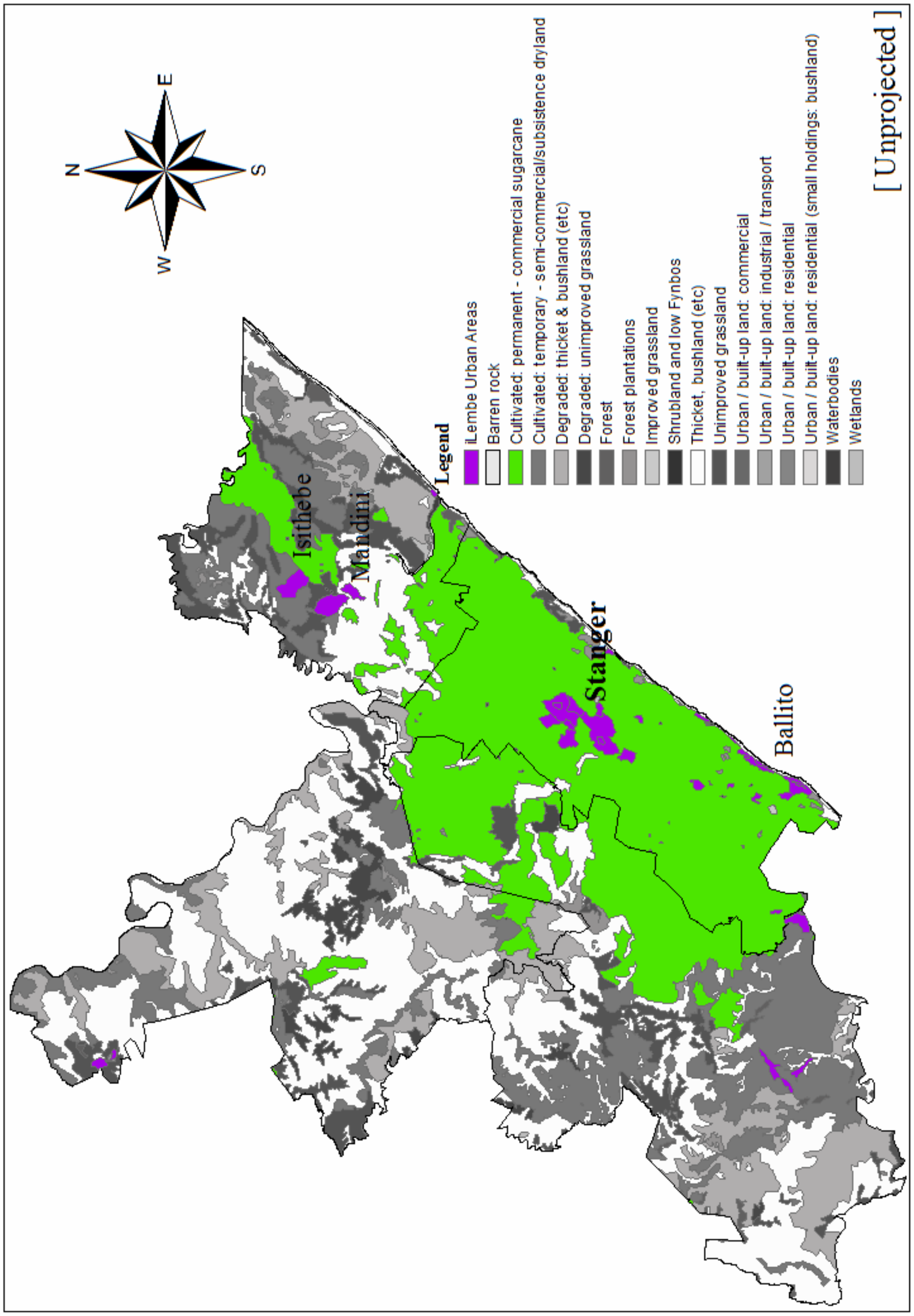

Figure 4.12: iLembe land use (source: iLembe GIS Database)

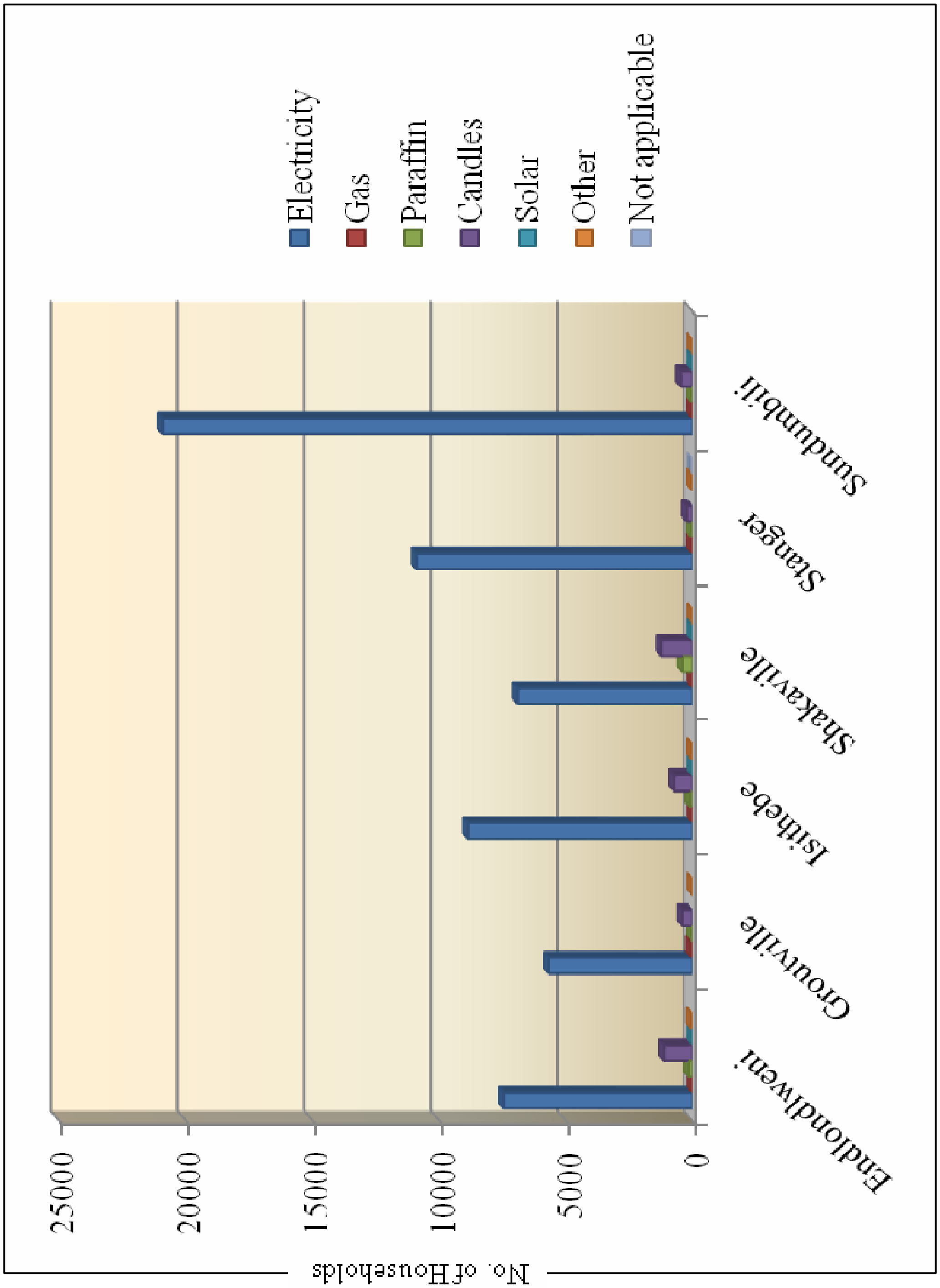

Figure 4.13: Bar graph showing household fuel sources for lighting (source: Statistics South Africa, 2001)

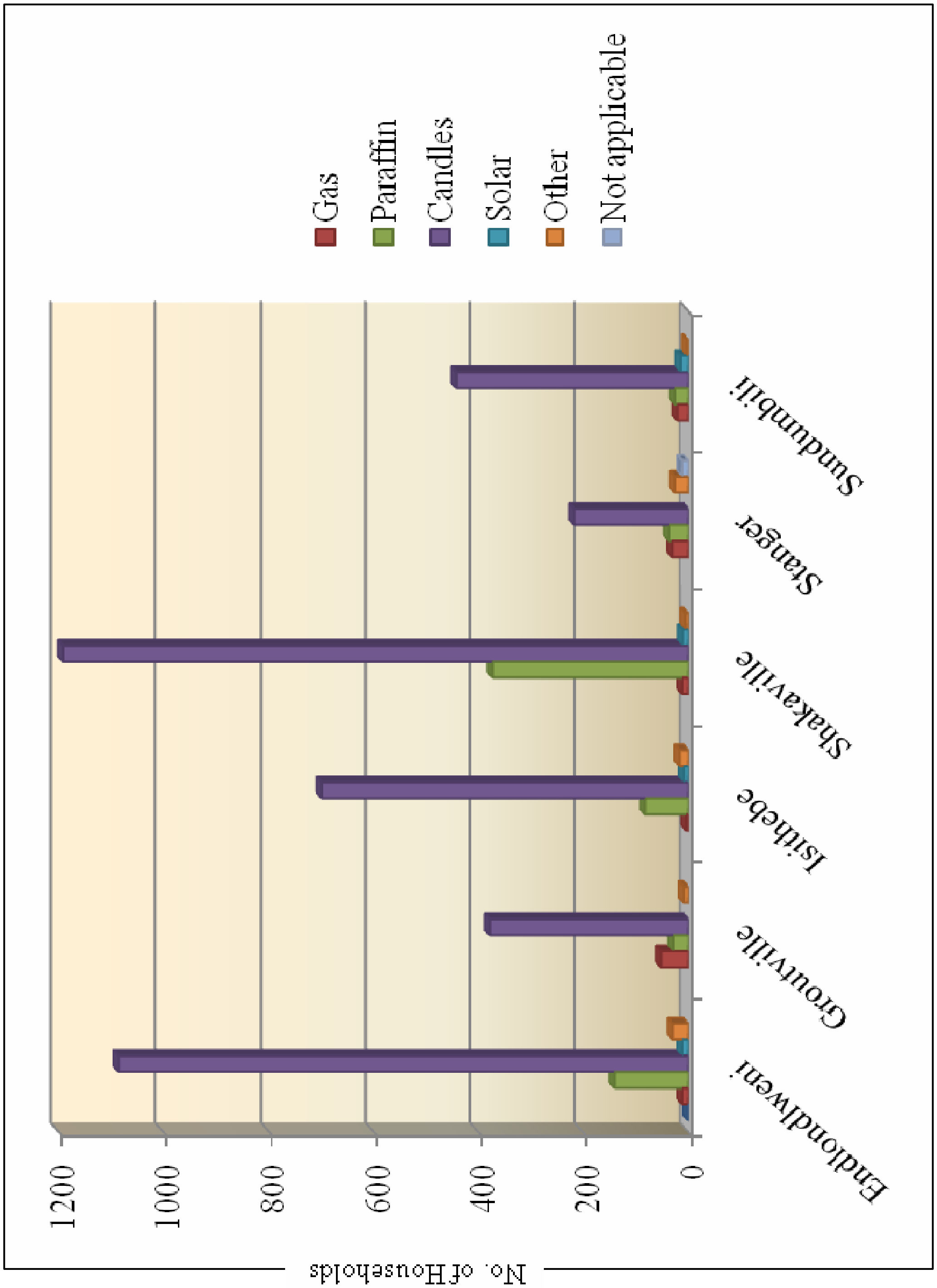

Figure 4.14: Bar graph showing household fuel sources for lighting excluding electricity (source: Statistics South Africa, 2001)

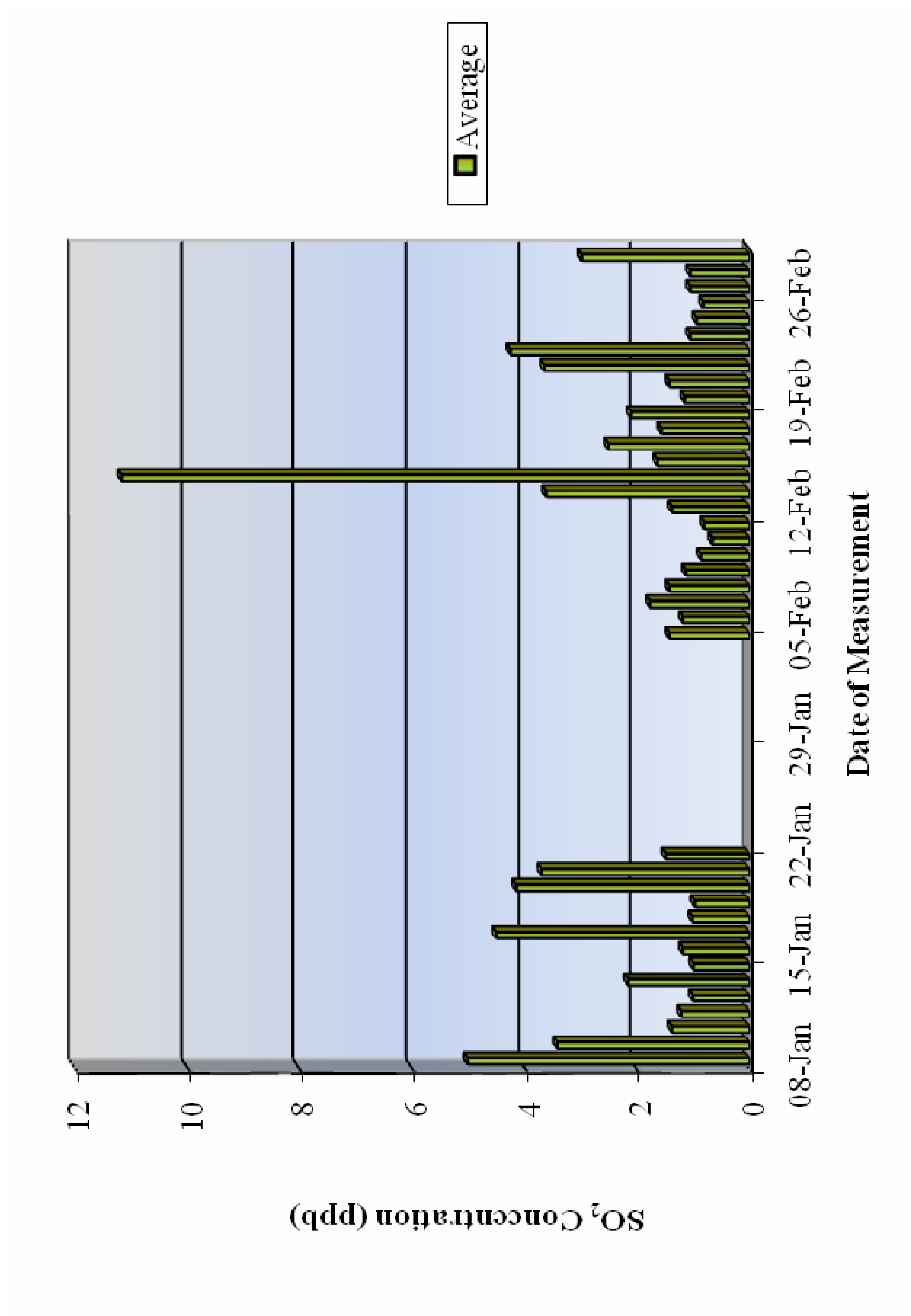

Figure 4.15: Bar graph showing measured SO_2 concentrations at Mandeni monitoring station for January and February 2007 (source: Mjoli *et al*, 2007)

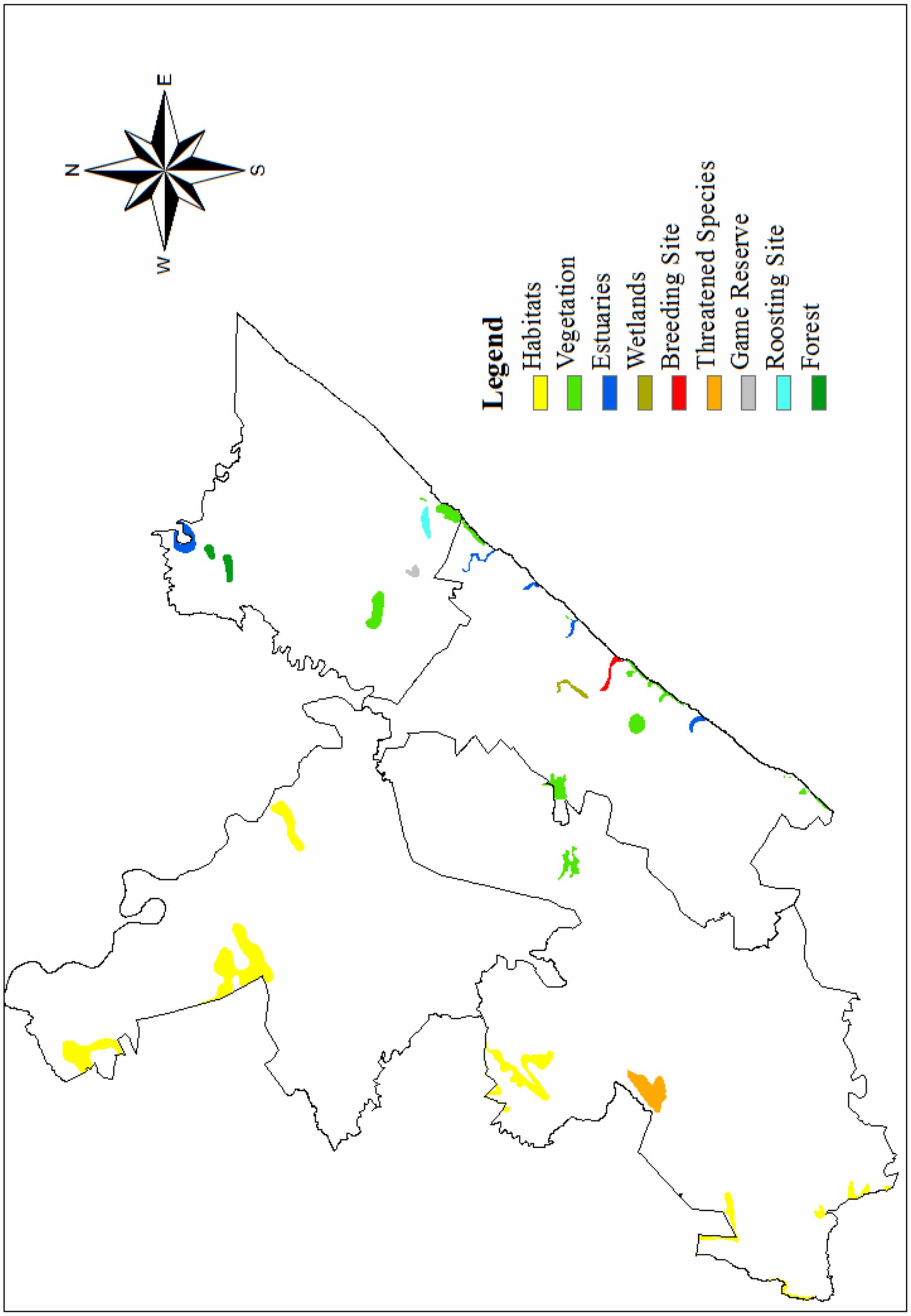

Figure 4.16: Sensitive natural environments (source: iLembe GIS Database)