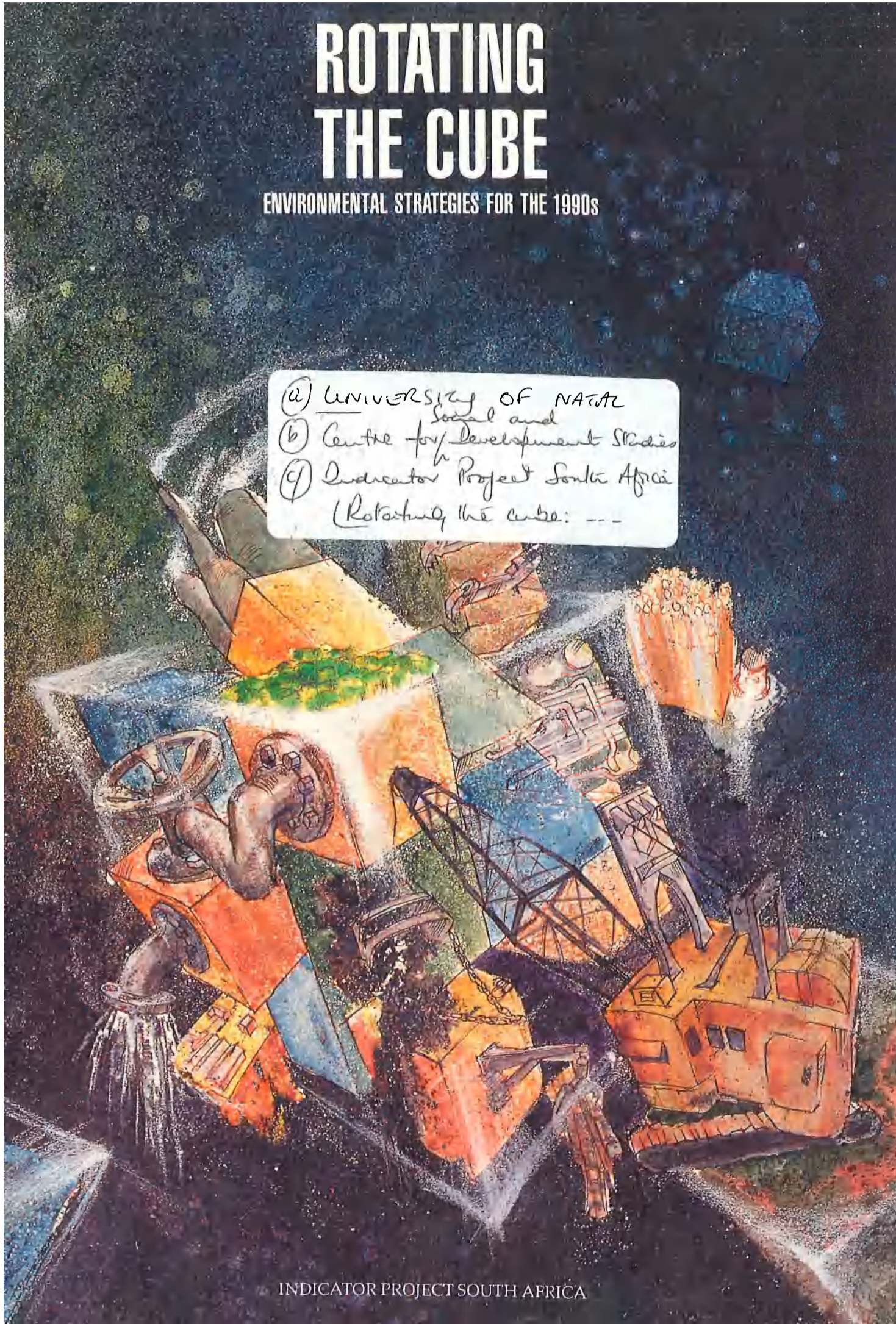


ROTATING THE CUBE

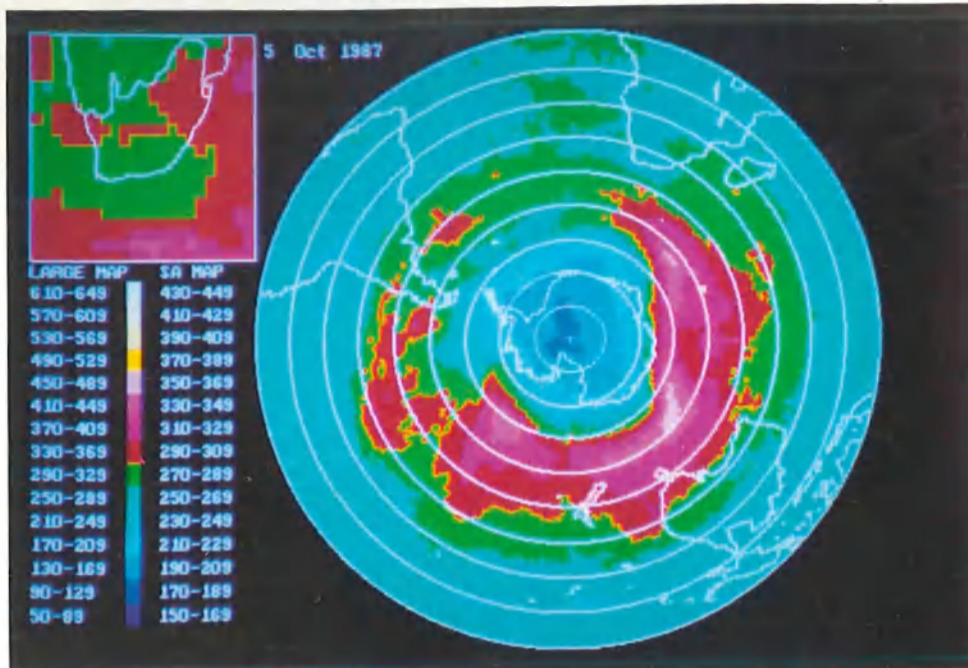
ENVIRONMENTAL STRATEGIES FOR THE 1990s

- (a) UNIVERSITY OF NATAL
Social and
- (b) Centre for Development Studies
- (c) Indicator Project South Africa
(Rotating the cube: ---



INDICATOR PROJECT SOUTH AFRICA

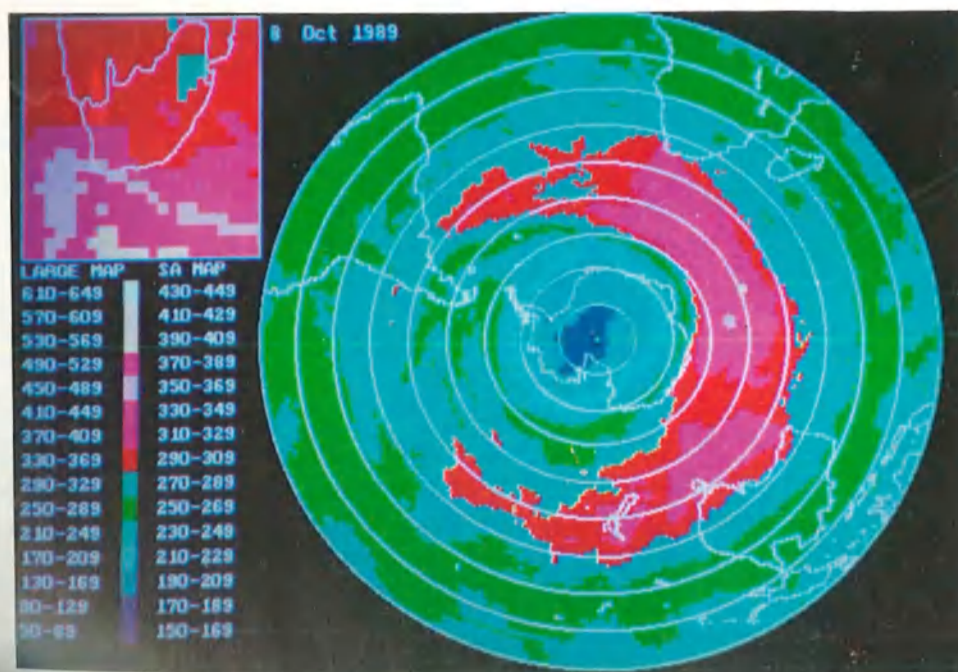
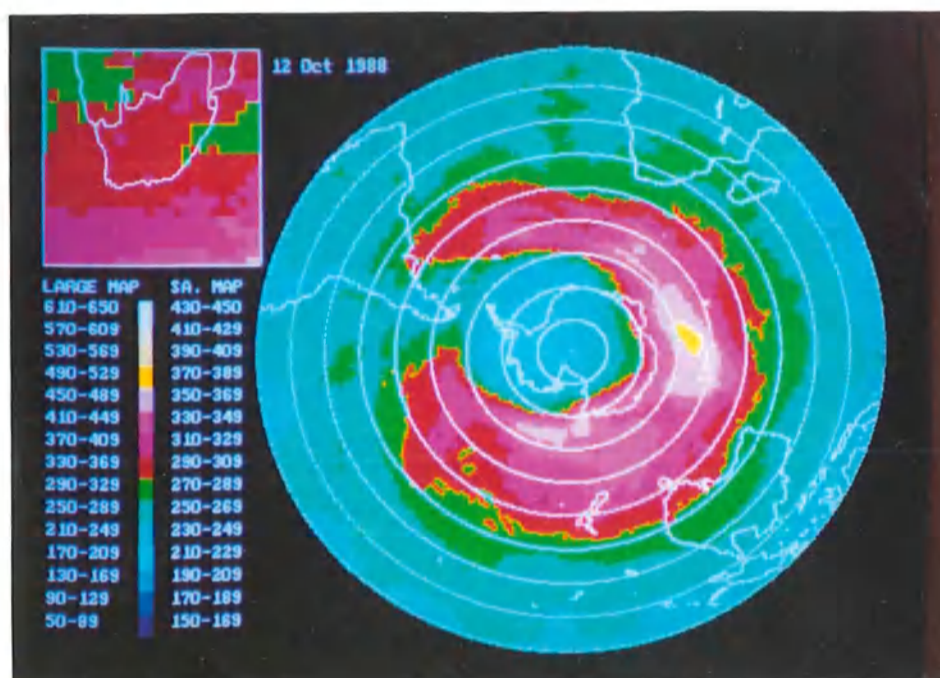
OZONE DEPLETION 1987 - 1989



These maps show the total ozone content (measured in Dobson Units [DU]) in a column above the surface for the Southern Hemisphere and South Africa (inset)

Low ozone values (less than 210 DU), shaded dark blue, clearly show the ozone hole in October 1987 (plate 1) and October 1989 (plate 3)

The absence of a deep hole in 1988 (plate 2) is an indication of the quasi-two year cycle in the severity of the ozone hole



The mid-latitude ridge of relatively high ozone values (red and magenta) surrounds the hole

Photographs courtesy of the Space Physics Research Institute, University of Natal, Durban

193859

ROTATING THE CUBE

ENVIRONMENTAL STRATEGIES FOR THE 1990s



An Indicator SA Issue Focus

April 1990

*Centre for Social and Development
Studies*

A joint publication

Department of Geographical & Environmental Sciences
Indicator Project South Africa
University of Natal

PUBLICATION CREDITS

Guest Editor *Rob Preston-Whyte*
Editor *Graham Howe*
Assistant Editor *Myrna Berkowitz*
Production/Design *Robert Evans*
Production Typing *Alan Van Zuydam-Reynolds*
Copy Typing *Beryl Cawthra*
Secretary *Patricia Fismer*

ISSUE FOCUS EDITORIAL COMMITTEE

*Rob Preston-Whyte, Graham Howe, Myrna Berkowitz,
Gerry Garland, Roseanne Diab*

- COVER GRAPHIC *Damon O'Beirne, The Bridge*
- INSIDE GRAPHICS *Jeff Rankin, The Bridge*
- PRINTING & REPRO *Robprint* • COVER REPRO *Hirt & Carter*
- FIGURE & PLATE REPRO *Cartographic Unit, University of Natal*
- ACKNOWLEDGEMENTS *Futurewave Technology, and Brother Industries*

- SPONSORSHIP We would like to thank several companies for their financial support of this special report:
Development Bank of Southern Africa, Hunt Leuchars & Hepburn Holdings Ltd,
Prefcor Holdings, Richards Bay Minerals, Sappi Ltd

ISBN: 0-86980-728-5

The INDICATOR SOUTH AFRICA Quarterly Report and the INDICATOR SOUTH AFRICA Issue Focus series are published by the Centre for Social and Development Studies, based at the University of Natal, Durban. Opinions expressed in these publications are not necessarily those of the Editorial Committee and should not be taken to represent the policies of companies or organisations which are donor members of the Indicator Project South Africa

© Copyright for all material herein is held by INDICATOR SOUTH AFRICA or individual authors, except in the case of short extracts for review or comment, which must be fully credited.

© Sole copyright for all data bases rests with INDICATOR SOUTH AFRICA. Permission to republish or reproduce any part of this publication must be obtained from the publisher.

ROTATING THE CUBE ENVIRONMENTAL STRATEGIES FOR THE 1990s

PREFACE:

One Earth *Ian Player* 5

INTRODUCTION:

The Environmental Rubic Cube *Rob Preston-Whyte* 8

PART 1: WATER, WATER, EVERYWHERE? 11

2020: Running on Empty *Alex Weaver* 13

The Age of the Aquifer *Brian Rawlins* 18

Waste not the Wetlands *George Begg* 21

Water Pollution: The Drowning Pool *Dean Simpson* 25

PART 2: THE AIR WE BREATHE 31

Where has all the Ozone Gone? *Roseanne Diab* 33

ILL Winds in Natal *Rob Preston-Whyte* 37

Jekyll-and-Hyde Herbicides *Mark Laing* 41

Cleaning up our Act *Rob Preston-Whyte* 46

PART 3: PLAYING WITH FIRE 51

Acid Rain, Global Greenhouse *Roseanne Diab* 53

Sing(e)ing in the Rain *Graham Howe* 56

Fuelling the Crisis *Peter Oxenham and Anton Eberhard* 61

Power Struggles over Energy Resources *Roseanne Diab* 64

PART 4: THE RAPE OF THE LAND 67

The Soil Spoilers *Gerry Garland* 69

Society's Waste Stream *Ray Lombard* 73

Of Mines & Men *Jeremy Ridl* 77

PART 5: FROM RESOURCES TO RICHES: INDUSTRY AND THE ENVIRONMENT 83

St Lucia: A Titanium Struggle

The Case For Dune Mining *Roy MacPherson* 85

The Case Against Dune Mining *Anthony Forbes* 89

The Conversion: Ozone Friendly Products *Ray Rivers* 93

Solutions to Pulp Pollution *Ben Coetzee and Chris Davies* 95

Environmental Education for Everyman *Roy Ballantyne and Pieta Tooth-Aston* 98

PART 6: THE DEMIGODS DILEMMA: MAN AND THE ENVIRONMENT 103

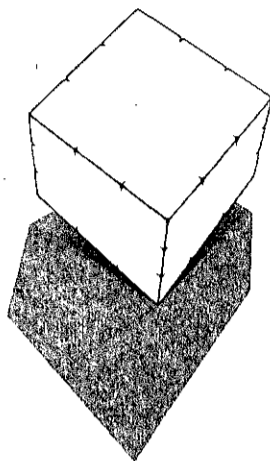
Development for People and the Planet *Bruce Corbett* 105

The Green Research Agenda *Tim Hart* 108

Conclusion : Rotating the Cube *Brian Huntley* 111

Preface

ONE EARTH



Dr Ian Player
Environmental Conservationist

With ten years to go to the twenty-first century, mankind is poised either to continue a destruction of the earth, historically unparalleled, or to learn to live harmoniously.

No-one in their thirties, or younger, will appreciate the vast and often terrifying environmental changes that have taken place in South Africa. Natal with its wonderful climate, variety of topography and abundance of natural resources has, in many places, changed beyond recall. It has borne the main brunt of the destruction. I compare my exploratory canoe journeys and early races down the Umsindusi and Umgeni Rivers of the 1950s to today: the staggering population growth, the pollution from industrial and human waste, soil erosion and the change in river courses, reduced as they are now to storm water drains. The Dusi and Umgeni of 1950 is another world.

I look too at the game reserves I worked as a young ranger in the 1950s. At that time there was no difference between inside and outside Hluhluwe, Umfolosi or Ndumu. Today they stand alone, islands amongst degraded habitats.

Television, newspapers and magazines tell us what is happening in the rest of the world. It is the same story of acid rain, of the elimination of tropical forests and all the other accumulated ills of the world that began changing after the industrial revolution.

Nothing has given us better understanding of this destruction than space exploration. The photographs and descriptions of the earth sent back by astronauts on their way to the moon or orbiting the earth clearly show the dilemma of a rapidly changing world at the hands of man. 'You can't stop

progress' has become a parrot cry of those who either do not take time to think or listen, or who believe that the only criterion is a financial one. The hidden and real costs could lead to the extinction of humanity, certainly to a drastic reduction in human numbers with all the concomitant financial repercussions.

*James Lovelock, author of **The Ages of Gaia**, says 'Amazonian forests the size of Britain are razed annually. This is depriving the earth of a cooling system'. Is it worth it for a few companies to convert virgin forests into cattle ranches to make a profit out of selling hamburgers? Truly what is one man's meat could be humanity's poison.*

How do we reconcile the apparently insuperable problems and take the harmonious way?

I firmly believe in the power of human innovation and our ability to cope when we understand the reality of what we face. In military terms Dunkirk was a retreat, but it was also a great victory because from it Britons learnt what they were up against. We are now only beginning to comprehend the dangers facing all mankind through environmental deterioration. Professor Preston-Whyte, in his introduction to this special report very succinctly gives an overview of the puzzle and enormity of resolving environmental problems. He states correctly that most people have difficulty in working out the Rubic cube but that there are some people who can simultaneously visualise all sides.

When the leaders of the earth can view our planet in a holistic way, it will be the equivalent of the immediate understanding of the puzzle of the Rubic cube. It was General JC Smuts who coined the term 'holism'. He was an intellectual giant ahead of his time. He came to realise on his walks across the Transvaal highveld looking at the masses of different grasses, that evolution is nothing but the gradual development and stratification of a progressive series of wholes, stretching from the inorganic beginnings to the highest levels of spiritual creation.

Smuts took half a lifetime to work out his theory. Many astronauts saw it in an instant flash, like the solvers of the Rubic cube, but they had the advantage of seeing our planet from outer space:

- Sultan Bin Salman al-Saud, a cosmonaut from Saudi Arabia looked down as he whirled above the earth and wrote: 'The first day or so we all pointed to our countries. The third or fourth day we pointed to our continents. By the fifth day we were aware of only one earth'.*
- A Syrian, Muhammad Ahmad Faris said: 'From space I saw earth - indescribably beautiful with the scars of national boundaries gone'.*
- Edgar Mitchell, astronaut and founder of the Institute of Noetic Sciences said: 'We went to the moon as technicians; we returned as humanitarians'.*

Smuts would have smiled. He would have understood these comments from the new men of space.

The harmonious way. In the unconscious of man it is an imperative. For two, perhaps three million years we lived in a state of unconscious balance, then man voyaged on an Apollonian path to scientific rationalism. It brought many benefits but ignored the ancient goddess.

*Edgar Whitmont in his incredible book, **The Return of the Goddess**, says:*

'A new mythology is arising in our midst and asks to be integrated into our modern frame of reference. It is the myth of the ancient Goddess who once ruled the earth and heaven before the advent of the patriarchy and the patriarchal religions'.

The Goddess is now returning. Denied and suppressed for thousands of years of masculine domination, she comes at a time of dire need ... Mother Earth herself has been pressed to the limits of her endurance. How much longer can she withstand the assaults of our rapacious industrial and economic policies? The patriarchy's time is running out. What new cultural pattern will secure for humanity a new lease of life on earth?'

The answer to Whitmont's question can be found in the rise of the feminine, the caring part of humanity. In an unintegrated way it is Woman's Liberation, but the true way is the holistic vision, the caring and understanding of the feminine by male and female.

*This, then, is the new harmony, the silent song, the holistic vision of the planet earth with the non-destructive use of technology. A tall order -yes. It will take us a long time to get there - yes. But we are beginning to move in the right direction. The findings and proposals of this Indicator SA special report are beacons on the path. **IPVA***

Introduction

THE ENVIRONMENTAL RUBIC CUBE

Professor Rob Preston-Whyte
Department of Geographical and Environmental Sciences
University of Natal

'The history of man is a series of conspiracies to win from nature some advantage without paying for it', is a comment attributed to the philosopher RW Emerson. The truth of this observation has long been evident to environmental economists who have often proclaimed on the impossibility of 'free lunches'.

The penalties for man's behaviour are at last emerging in the public consciousness and are being reflected in the mass media. Much of the fore in recent months has been the plight of the Black Rhino, dune mining in the St Lucia area, global warming and the hole in the ozone layer. Each of these human impacts on the environment is the result of trying to win from nature some advantage without paying for it.

How do we begin to address environmental problems? First, we must recognise that environmental decision-making is a complex exercise which may involve economic, political, cultural, legal, technical and environmental inputs. The difficulty of incorporating and weighing each of these six considerations in the environmental decision-making exercises is similar to that of resolving the Rubic cube.

It may be recollected that the Rubic cube is a puzzle involving a cube with six colours on movable blocks. The objective is to arrange the cube so that each of the six sides contains a single colour. Many have spent hours (or months) attempting to match colour and side on this tantalising toy, yet there are those who can resolve the puzzle in less than a minute.

The reason for their success is that, while the less competent attempt to arrange the colours on one side before moving to the next, the accomplished are capable of visualising all sides at once. With this information they are amply prepared rapidly to arrange the colours on each side of the cube. Since most of us fall into the category who find the resolution of the Rubic

cube problematic, it is hardly surprising that environmental decisions, which require a weighed evaluation of various inputs, tend to be sub-optimal.

The problems of environmental management can be developed further. Human impacts on the environment start when resources are identified, extracted and refined in order to satisfy the needs and wants of society. This is a cultural activity for we can only recognise resources through the eyes of our culture. Stone age man would have ignored an oil well. The efficiency and nature of our need and want satisfaction relates to the technological and managerial abilities of our culture.

Unfortunately, the act of acquiring goods and resources produce environmental impacts in the form of air and water pollution, soil erosion and solid waste disposal problems. Until recently, many of these impacts have gone unnoticed. However, we are now in the process of recognising these impacts and beginning to debate the benefits and costs of resource uses. For example, are coal-burning power stations, with their resulting acid rain and health problems, more or less damaging to the environment than nuclear power stations?

The process of impact recognition is also a cultural activity since it may derive from the form and level of education of the members of the society. How to cope with environmental problems involves a feedback activity which draws on the accumulated wisdom of the society, which, in turn, is embedded in its political and legal system and its technological and managerial skills (see figure 1).

A society can act most efficiently through its political and legal structures if all the members of the society can agree on how to conduct their affairs. This common feeling is expressed by the ideology of the society.

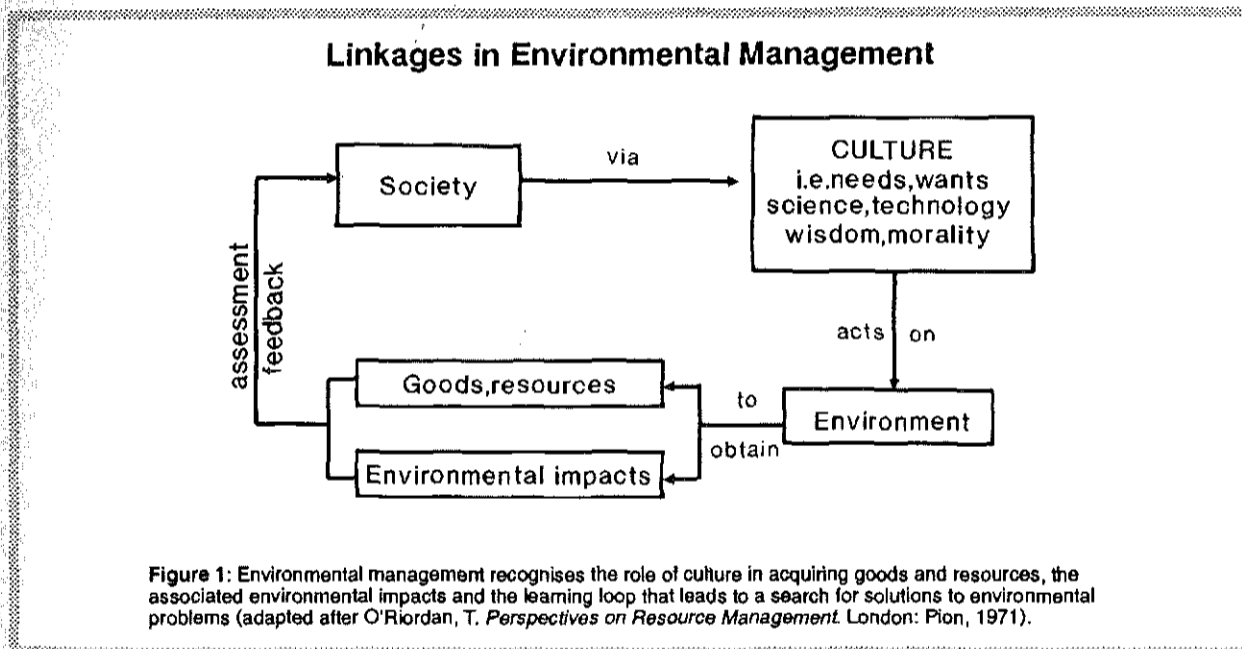
An environmental ideology, therefore, would express a common attitude towards the environment. We all would admit to some form of environmental ideology obtained through family links, schooling and church influences. The problem, however, is that we do not all share *the same* environmental ideology. Instead there may exist a wide ideological spectrum in the same society. Examples are the so-called 'Greens' which tend to occupy one side of the ideological spectrum, with technocrats at the other end.

In the absence of a shared environmental ideology, inadequate directives or no directives are relayed to our political representatives in government. This results in the relegation of environmental issues to the tacitly recognised agenda for non-decisions. Alternatively, when environmental decisions are made by central or local government, the debate is influenced by conflicting attitudes held by people with different environmental ideologies. Rather than

External costs are, therefore, passed on to the consumer who eventually pays both actual and external costs.

The problem of how to internalise external costs and thereby minimise pollution is the subject of ongoing debate. It is certainly one of the components of the environmental Rubic cube. Essentially, it involves eliminating the free use of common property resources (atmosphere, water bodies, etc.) for the dumping of wastes and adding the costs of cleaning up the environment to our taxes and to the price of products and services. However, this requires acquiescence by society through its political system, which in turn necessitates a shared environmental ideology.

Inevitably, the solution returns to the need for society to solve its environmental problems through its political and legal systems. To do this, however, members of society must judge what balance of benefits and costs are

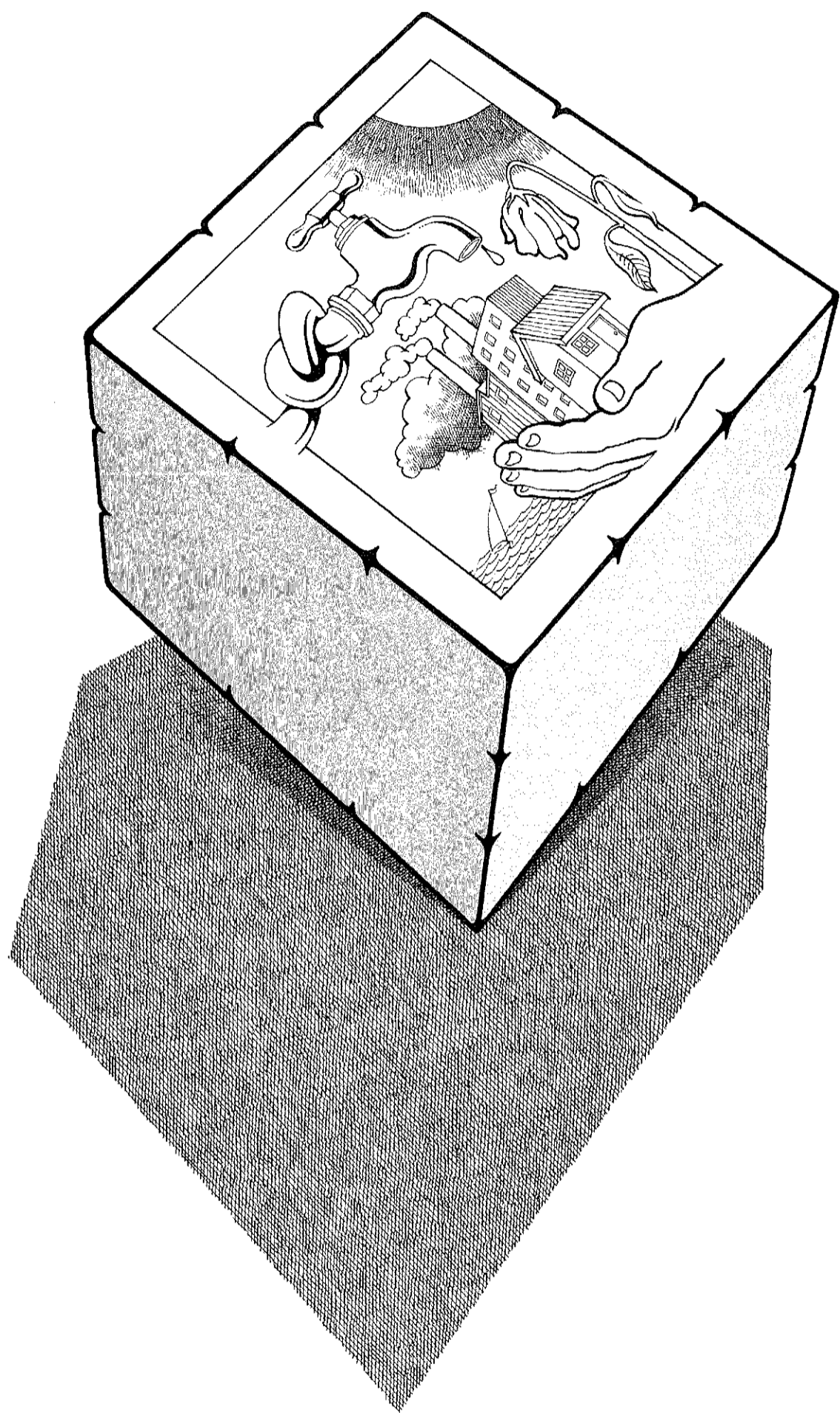


encourage sound decision-making through thorough debate, decisions which impact on the environment may often be taken by people capable of wrestling with only one side of the environmental rubic cube.

In economic terms, the production of goods and services generates both internal costs and benefits. However, the true costs of goods and services, which should include internal costs, is seldom evident. Pollution in its various forms is, therefore, largely a problem of failure to include the hidden costs of poorer health, increased cleaning bills, etc., in the cost of production and services. Instead our present system makes it profitable to pollute, since the manufacturer is only required to pay the cost of production.

acceptable. They must then ensure that their political representatives receive and are responsive to their demands, so that effective corrective measures can be taken through environmental education, economic strategies, legislation and research.

Returning to the Rubic cube, we are presently faced with environmental problems the solutions to which are scrambled like the cube when all colours are mixed across all sides. However, we can optimistically recognise that much knowledge and understanding in relation to each of the six sides of the Environmental Rubic cube has been acquired over the years. The challenge of the 1990s will be to see if we can learn how to resolve it. **IPQA**



© 2000 by the Board of Regents of the University of Wisconsin System. All rights reserved. This work is the property of the Board of Regents of the University of Wisconsin System and is not to be distributed, reproduced, or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without the prior written permission of the Board of Regents of the University of Wisconsin System.

Part 1 Overview

WATER, WATER, EVERYWHERE?

In 1674 the French naturalist, Louis Perrault, offered the first hydrological account of 'l'Origine des Fontaines' (the origin of springs). His analysis provided the basis for developing the concept of the hydrological cycle, and ultimately allowed the German scientist Bruckner, in 1905, to propose the notion that the earth and its atmosphere exist in a closed hydrological system. Put simply, this means that on a global scale water can be neither destroyed nor created - the total quantity of terrestrial water is fixed, and can never change.

Water of the world is stored in three sub-systems. By far the greatest quantity - some 97% - is held in the oceans, and a great deal less than 1% resides in the atmosphere. Almost 3% is on or below the land, and forms our main water resource. Since well over two-thirds of this is locked up in the polar ice-caps, and is unlikely to be seriously exploited as a resource in our lifetimes, it is really only about 1% of total world water that is available for potential human use.

At first sight Africa's share of that 1% - approximately 3m cubic kilometres - seems generous. But 99% of it is found in lakes and underground reservoirs which have taken millions of years to accumulate, and is not replaceable in the short term. Its large-scale use is like mining gold or pumping oil - a non-renewable resource is being exploited.

The main renewable water resource is stored in river channels and catchments, where about 630 cubic kilometres may be found. Africa's river water is renewed on average about 24 times each year, and total renewable water is therefore in the order of 15 000 cubic kilometres per year. Even this seems fairly substantial - it would fill a lake 30 by 500 kilometres in size to a depth of 1 kilometre - until it is compared to water requirements. A town of 100 000 inhabitants needs about 1 cubic kilometre per year to satisfy domestic, commercial and industrial requirements.

South Africa's water resources should be considered within this global and continental context. The country is one of the largest water users on the continent, although its renewable resources are a mere 32 cubic kilometres per year. It is already negotiating to purchase water from adjacent countries. In the following section, a number of specialists explain changing patterns of our demand for water. They assess actual and potential sources of water supply, taking into account particular features such as the role of aquifers and wetlands, and they propose environmental strategies to reduce the effects of water pollution.

Case Study 1

2020

RUNNING ON EMPTY

Dr Alex Weaver
 Department of Geography
 Rhodes University

Much is being said at present about future development in South Africa in both the political and economic fields. Many of the scenarios make little, if any mention of the severe restrictions that our meagre water resources will place on development in the twenty-first century. The severe droughts which hit South Africa in the 1960s and the 1980s served to highlight the extreme spatial and temporal heterogeneity in the supply-demand relationship of the country's water resources.

The average annual rainfall for South Africa is 483mm compared to a world average of 860mm. We are, therefore, by definition a dry country. South Africa is relatively poorly endowed with suitable groundwater supplies and over 80% of the country's water requirements are met by surface supplies. The magnitude of these surface water supplies is directly dependent on rainfall.

There are large seasonal variations in both rainfall and runoff in South Africa. Only 3% of the country receives good year-round rainfall; 86% of the country receives its rain in summer. By contrast the south-western Cape, covering 11% of the country's total area, receives winter rainfall with summer droughts. Variations in the availability of surface water in South Africa is ultimately dependent on precipitation, which is variable in both the short- and long-terms.

Superimposed on the temporal variability in supply are both seasonal and long-term variations in demand. On a seasonal basis, irrigation demands, which constitute approximately 75% of the total demand, peak during the growing season. For example, vineyards under irrigation in the Bree River Valley receive an average of 100mm irrigation water per month between October and March but only 30mm between April and September.

Few scenarios examine the restrictions placed by meagre water resources on development in South Africa

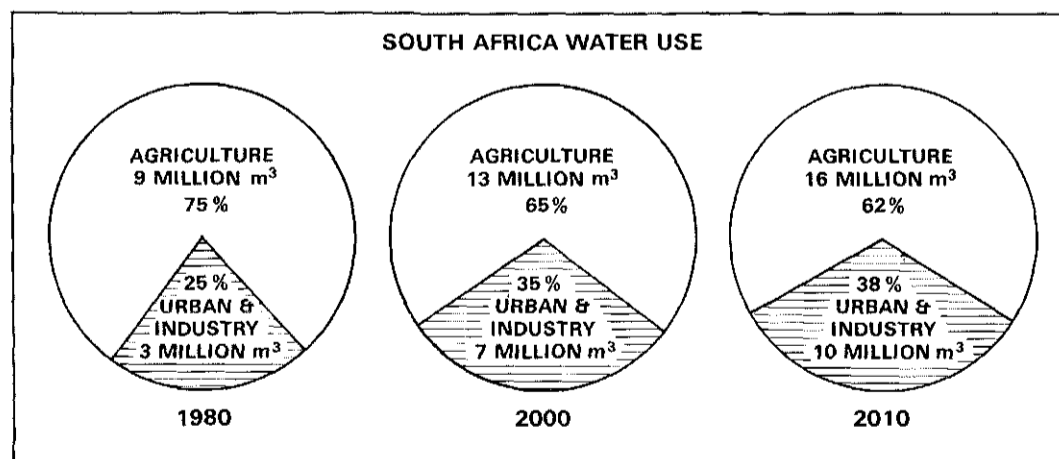


Figure 1: Projected water use in South Africa

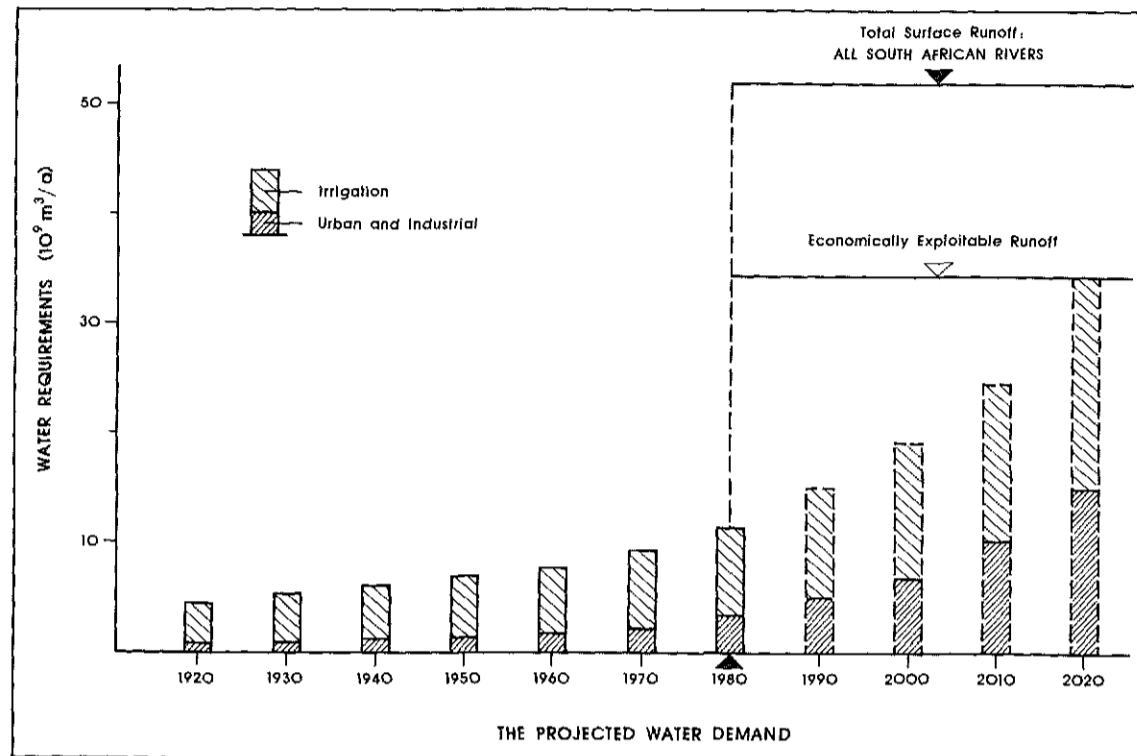


Figure 2: Long-term trends in surface water demands in South Africa

The domestic and industrial demand for water in South Africa will outstrip the available supply by the year 2020

Urban and industrial water requirements remain fairly constant throughout the year. Water resource managers therefore have been forced to construct large-scale storage dams to sustain variable seasonal demands on water. Creating unwarranted storage ahead of demand ties up capital, imposes an interest burden and increases the salinity of the stored water and the rate of sediment accumulation in dams.

Until fairly recently, the development of water resources was mainly for agricultural purposes. With expected changes in the nature of the economy due to urbanisation and a growth in the manufacturing sector, water usage patterns are expected to change.

It is expected that agricultural demands on the total water budget will be tailored from approximately 77% to 60% with a concomitant increase in urban and industrial use to 40% of the total water use by the year 2010. The most disturbing aspect of the long-term trend is that the demand for water will outstrip the supply by the year 2020.

Temporal inequality in the supply-demand ratio is not the only problem facing the management of South Africa's water resources. Major spatial disparities also occur. There is a wide range in mean annual rainfall for the country. Our annual rainfall ranges from less than 100mm per annum in the west to over 2 000mm in places in the highlying regions of Natal and the eastern Transvaal. Over 75% of the country's mean annual rainfall falls in the 400km wide coastal zone in the east, stretching up from East London. By contrast, the dry north and north western region of the country, encompassing 65% of the total area, receive only 15% of the rain.

The average annual amount of water received from rainfall is estimated at approximately 600 000 000 000 m³. Only 9% of this eventually contributes to streamflow due to losses to evaporation, evapo-transpiration (use by plants) and seepage. In a nutshell, it can be estimated that only 60% of annual rainfall is available for beneficial use (i.e. 32 000 000 000 m³).

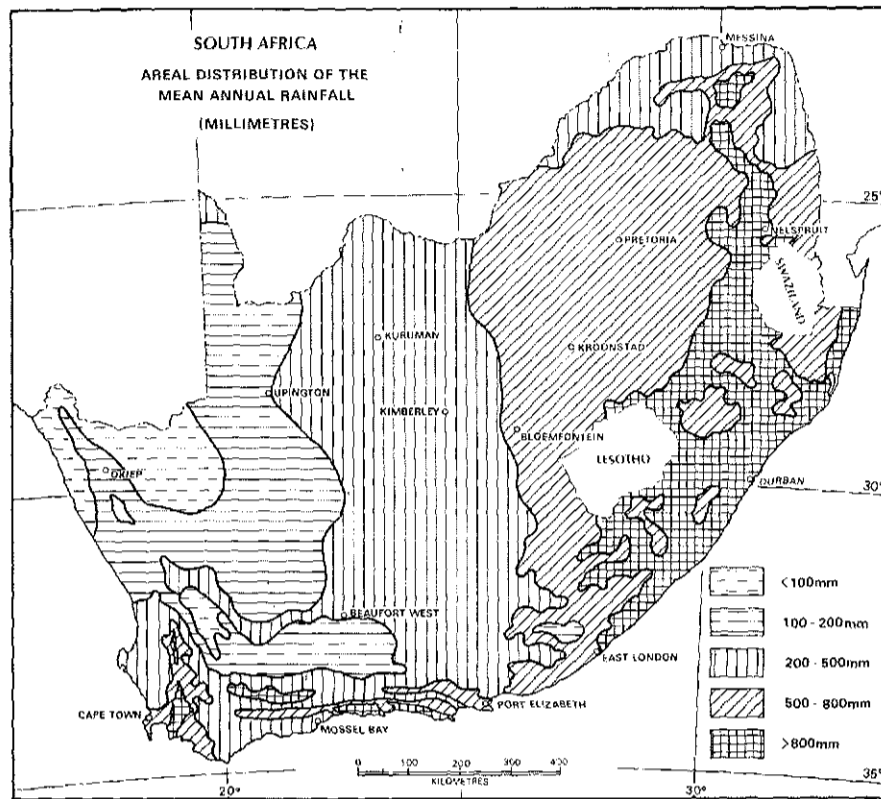


Figure 3: Distribution of average annual rainfall in South Africa

Changing Pattern

The present demand for water can be related to a highly irregular spatial pattern in terms of the overall distribution and the concentration of water users. Although irrigated farmland occupies only 0,7% of the country's land area, irrigation makes up 75% of the total water demand. The present trend within the total water budget is characterised by

dramatic increases in urban and industrial consumption relative to that of irrigation, reflecting a re-orientation in the overall demand and a change in the economic structure. It is expected that by the year 2010 there will be a 50-50 split in consumption between irrigation and urban and industrial users.

Urban and industrial usage of water is also highly localised, with nearly 40% of

At present, there is a dramatic increase in urban and industrial consumption of water relative to agricultural usage

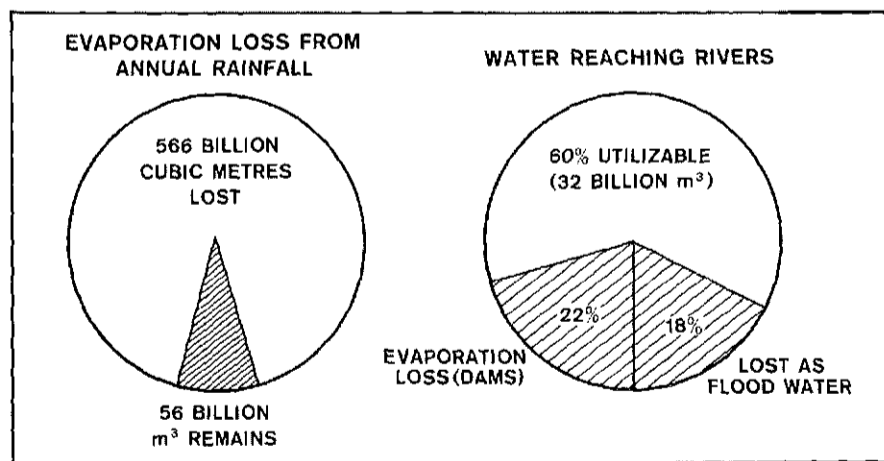


Figure 4: Estimated surface water losses in South Africa

Not only is our water running out, it is not naturally available where and when we need it

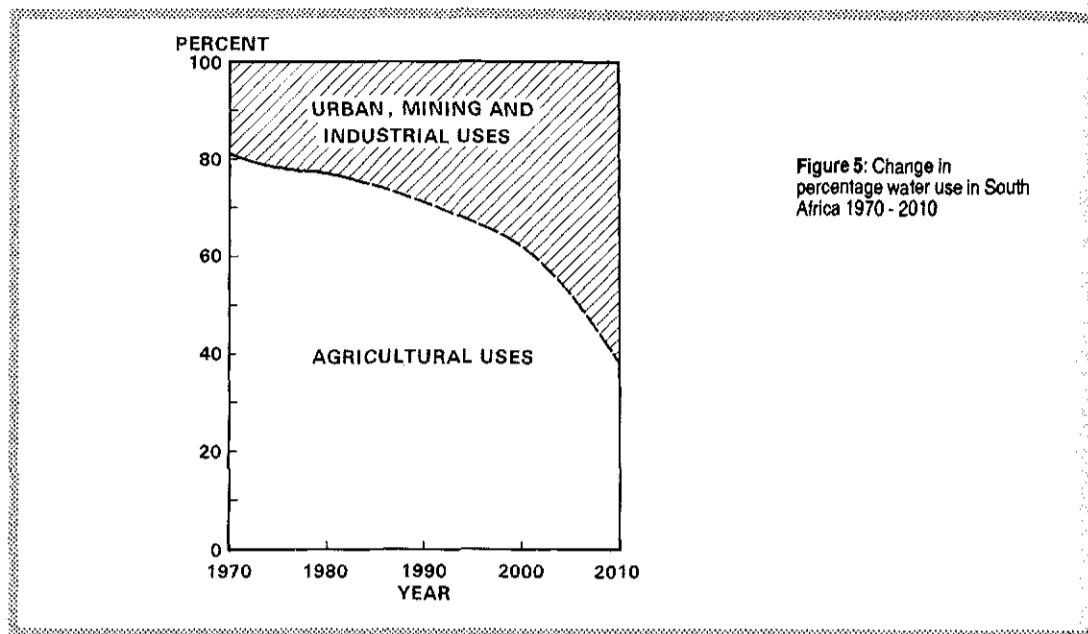


Figure 5: Change in percentage water use in South Africa 1970 - 2010

the country's population being situated in four primary nodal regions (the Pretoria-Witwatersrand-Vereeniging area (PWV), Cape Town, Durban-Pinetown and Port Elizabeth-Uitenhage areas). These four regions occupy only 2% of the Republic's land surface yet account for 80% of our manufacturing output and 76% of the industrial employment.

Put simply - not only is our water running out, it is not naturally available in sufficient quantities where and when we need it!

Increasing urban and industrial demands on water and marked increases in living

standards have led to a demand trend which is rapidly approaching the total potential supply in the country. Even if demand could be contained through more realistic pricing and stricter control, and supply possibly increased through advanced technology, the future of the country's water resources will still require urgent attention. The implications of a shift in emphasis from predominantly agricultural (rural) to predominantly urban consumption are numerous. One of these being that the demand for water is becoming more centralised, requiring a greater degree of water transfer from areas of supply to meet this demand.

The water demand is becoming more centralised, requiring greater water transfer from areas of supply

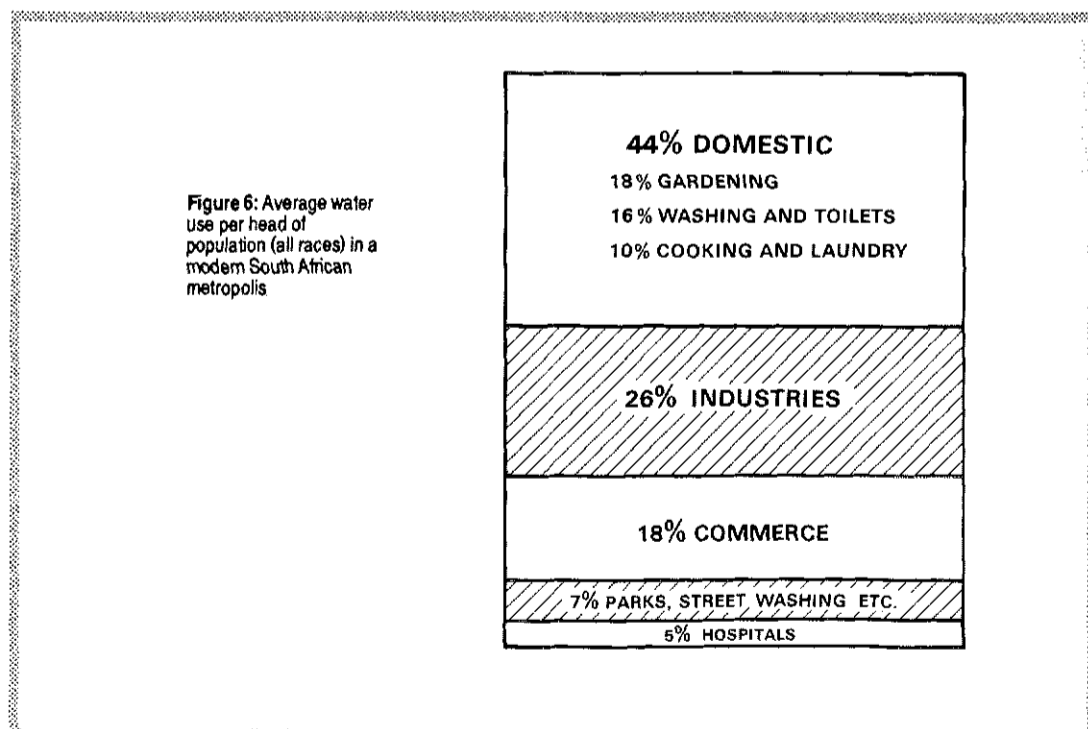


Figure 6: Average water use per head of population (all races) in a modern South African metropolis

Solutions

South African water engineers have for some time been putting forward proposals regarding the importation of water from neighbouring countries. These schemes include long-distance pipelines from the Okavanga and Zambezi systems. Political uncertainties in the sub-continent remain the most important stumbling block to the co-operative development of the region's water. The PWV area faces the most urgent water supply problems in the country.

The Lesotho Highlands scheme (now being implemented after being on the drawing board for thirty years) will result in an extra 2 200 000 000 m³ water per year for the Vaal River. It is estimated that this scheme will postpone the 'drying up' of the Vaal River by 14 years to the year 2014. It should be noted that this does not represent a new source of water to South Africa but rather a diversion of water from the Orange River (which flows into the Hendrik Verwoerd dam) into the Vaal system.

In contrast to the PWV area, Natal and KwaZulu are well watered (mean annual rainfall exceeds 1 000mm) and current predictions are that the area could enjoy the longest assured supply of water in the country. A major limitation which faces Natal water supply schemes is the high rate of sedimentation in some of the storage dams. It is imperative, therefore, that effective soil conservation be considered as an integral part of water resources planning in the region. Another possible 'threat' to the water resources of the area lies in the demand for water in and transfer of water to the PWV area.

Increased population pressures and increased living standards of black consumers will result in significant increases in water demand. The average per capita consumption of water by blacks in the Eastern Cape is thought to be in the region of 20 litres per day whereas that of white communities is

closer to 300 litres per day. It has also been shown that water consumption amongst black water consumers has more than doubled over the past 20 years whilst white per capita consumption has remained fairly constant. It seems likely that the envisaged easing of the various political, legal, structural and institutional constraints and controls will result in increased water demands in this sector.

A potential threat to our water resources which was highlighted by events in the Crocodile River catchment recently is industrial pollution. Given the already excessive demands on water in South Africa and the poor and unreliable supply, we can ill afford a reduction in the resource base due to toxic waste contamination.

Environmental legislation will have a vital role to play in both the policing of water and in ensuring that poorly planned development does not affect our supplies. Stricter application of environmental impact assessments is in the long term interest of all our users.

The judicious use of the surface water supplies of South Africa is essential if predicted future trends in industrialisation, urbanisation, agricultural development and population growth are to be adequately sustained.

Equitable distribution of water to the various users is adversely affected by spatial and temporal disparities in the availability and consumption of water in South Africa. Improved technology, alternative water sources and reduced consumption of water can provide short term solutions to the water scarcity problem. Future development policies can help in alleviating many of the long-term water supply problems if cognisance is taken of the temporal and spatial heterogeneity, and of the economic and ecological importance of what is one of South Africa's most essential resources - water. **IPWA**

Increased population and living standards of black consumers will increase water demand

Environmental legislation will play a vital role in policing water and in halting poorly planned development

Case Study 2

THE AGE OF THE AQUIFER

Brian Rawlins
Department of Hydrology
University of Zululand

The development of ground water resources (aquifers) has intensified as surface water supplies dwindle

In many cases aquifer yields are only sufficient for small-scale domestic or agricultural supplies

Ground water is one of the most important natural resources that are exploited for human benefit. It forms over 20% of the total reserves of fresh water on earth and in many regions it is the only permanent source of water. The development of ground water resources has intensified this century because yields from the more readily available surface water sources have been unable to cope with a rapidly increasing demand.

Ecological and environmental consequences of this increased ground water use are related to the development of industry, agriculture, urbanisation, growth of population and an increase in the quality of life. The quantity and quality of the existing ground water resources can be adversely affected by these developments on a range of scales from the local to the continental level.

In the exploitation of a ground water resource, it is therefore essential that proper environmental management is undertaken. Careful management, however, is difficult in view of the problems associated with the full comprehension of the hydrological behaviour of an aquifer. Far too often, aquifers are only investigated in detail once undesired conditions have arisen. This is partly due to a lack of sufficient data with which to analyse the aquifer before its exploitation, and partly due to a failure of the developers to recognise the environmental consequences of their actions.

Ground water has not attained the same level of importance in the national water supply for South Africa as it has in other parts of the world. The level of development in South Africa is, at present, such that in most cases the

surface water resources have been sufficient to meet demand. It is only in areas that have already experienced severe water shortages that the ground water resources have been extensively developed. Additionally, South Africa has a paucity of good ground water sources, so in most cases the aquifer yields are only sufficient for small-scale domestic or agricultural supplies.

The distribution of reserves, outlined in figure one, shows that the extensive, high yielding primary aquifers (those composed of unconsolidated deposits) are few and that they are situated well away from the centres of development. Consequently, even though they contain substantial quantities of exploitable water, they are, in most cases relatively undeveloped. The more numerous primary aquifers found in river valleys are of much smaller areal extent and have a low storage capacity. Their yields are therefore generally low, so their development is restricted to supplying individual local needs.

In the remainder of the country, which is underlain by old, hard crystalline rocks, the ground water potential is low. It is only in specific areas where the rocks have been weathered or fractured that there are significant resources. The majority of such areas are in the extensive dolomite formations that underlie the central area (see figure 1). Here there are good supplies that have been developed.

During the coming decades, in response to increasing water demands, the role that ground water is to play will increase dramatically. The surface water resources are nearly exploited to the full. With the exception of costly inter-basin transfer

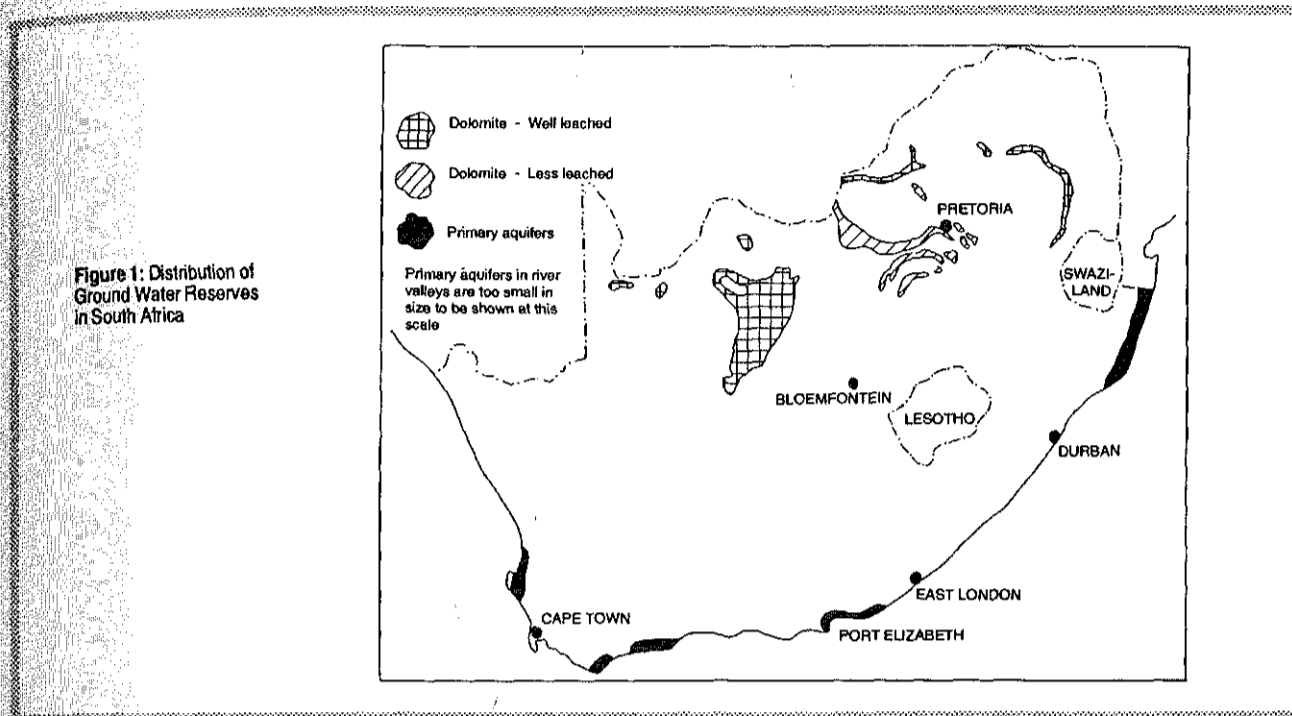


Figure 1: Distribution of Ground Water Reserves in South Africa

schemes, increased ground water extraction is the only feasible solution to the problem.

Allied to ground water extraction, however, there are many inherent environmental problems. These consist of the direct environmental influence resulting from increased pumpage, and also the indirect response to human development of the aquifers.

Environmental Impact

The environmental problems associated with the extraction of ground water result from a depletion of the water in storage. They include a reduction in the supply of recharge from the ground water body to neighbouring surface waters, the development of sink holes at the surface and, in coastal areas, the intrusion of saline water to the aquifer.

The depletion of the water held in storage may in many cases have only minimal environmental implications. The water held in the upper regions of an aquifer generally has a short residence time and consequently, it would be naturally discharged if it was not pumped. However, in areas where this natural discharge is responsible for maintaining surface flow in dry periods, the reduction in discharge can adversely affect the surface hydrology. In extreme cases, it can cause rivers to become ephemeral or

intermittent. The resultant effect on stream biota can be serious.

The development of sink holes after ground water has been extracted for supply or for dewatering projects is well-documented. Some of the most dangerous and dramatic collapses have occurred in limestone areas due to mine dewatering. In the far west Rand, gold mining has required the abstraction of water to such a degree that the local water table has been lowered by more than 300 metres. The consequences are that the structural integrity of the aquifer is impaired and, in addition to the creation of voids previously filled with water, there can be a drying and shrinking of clays within the rock matrix. This can lead to instability and collapse. These collapses are reflected at the surface by depressions (sink holes) that can be large and deep.

Invasion of saline water due to ground water withdrawal is a common problem in coastal aquifers. As fresh water is extracted from such aquifers there is a major change in the position of the fresh water-saline water interface. A one metre drop in the water table will result in a forty metre rise in the interface, bringing the saline water body further inland and closer to the surface. Continued unmanaged pumping can, therefore, have disastrous effects on the quality of water within the aquifer and thus render it unusable.

Human development of aquifers requires careful environmental management to minimise the ecological impacts

The prevention of pollution is the only really effective way to protect water resources

Only 20% of South Africa's total water requirements are ever likely to be met by ground water supply

These environmental problems, caused by uncontrolled or badly managed extraction of ground water can all be mitigated with competent geohydrological management. If the aquifers are fully understood then it is possible to determine safe yields and to maintain conditions at something approximating the status quo.

Solutions

By far the most serious effects of the development of ground water supplies are those resulting from pollution. Once contaminants reach ground water, they are not effectively diluted and dispersed because the rate of movement of most ground water is very slow. After contamination, an aquifer will remain polluted for many years and it is difficult or impossible to remedy the situation.

The major sources of pollutants are leaks from underground storage tanks (petrol and other chemicals), seepage from landfill waste dumps and accidental surface spills of chemicals. The major problem in the control of this pollution is one of detection and monitoring. A pollutant source can go undetected for many years, and once discovered, the aquifer may be in such a condition that remedial measures are difficult and extremely costly. Prevention of pollution is therefore the only really effective way to protect the water resource.

This prevention will only be possible with strictly enforced legislation, together with a high level of environmental responsibility from the industrialists and developers. The monitoring and policing of aquifers in South Africa is necessary. Perhaps this could be undertaken by an agency similar to the Environmental Protection Agency operating in the United States of America.

The current status of ground water use in South Africa is such that environmental issues have yet to be addressed fully. As only 20% of the total water requirements of the country are ever likely to be found from ground water and as only 12% of the ground water extracted is for domestic and industrial supplies, surface water environmental issues have taken priority. However, it is evident that as over 65% of the country on an area basis is dependent on ground water, it will become increasingly necessary for these scarce resources to be managed on an environmentally sound basis.

In Natal, the problems associated with overexploitation are small due to the reliability of surface water supplies. Nevertheless, the increasing urban and industrial development in specific areas will necessitate sound environmental policies for the future well-being of the province. Additionally, the expected population increase will lead to a greater water demand and a higher incidence of pollution in the rural areas. This will obviously have a significant effect on the quantity and quality of ground water.

The use of integrated environmental management techniques to conserve the available resources is an urgent need. As yet, however, these techniques are relatively new to South Africa. The main thrust of environmental research should be in this direction so that development can proceed in a planned way with minimal adverse consequences on the environment. This is not to say that development must suffer due to environmental conservation needs, but rather that development must be programmed to have as small an impact as is possible on the water resources, on which it depends. This is especially so in the many areas of South Africa that have been recognised as being particularly sensitive to environmental disturbance. **IPUA**

Case Study 3

WASTE NOT THE WETLANDS

Dr George Begg
Consultant,
Environmental Advisory Services

To most people, words such as 'marsh, swamp, bog and vlei', collectively referred to hereafter as wetlands, conjure up little more than the 'four D's' - dampness, disease, difficulty and danger. Because of this perception wetlands have been regarded as wastelands which, wherever possible, should be converted to alternative uses such as cropland, dams, plantations of exotic trees, waste disposal sites and pastures, or reclaimed for industrial land and the construction of airports, harbours and sewage treatment plants.

However, it is important to place into perspective the implications of such decisions. Associated with the alteration of wetland habitats there are hidden costs, which South African society can ill afford to overlook. Here an attempt is made to review the characteristics that are common to all wetlands, to explain why they perform valuable functions, to examine their current conservation status in South Africa and to highlight the implications of any further decline of these resources.

Functions and Features

Wetlands have been an enigma to many people. They combine attributes of both aquatic and terrestrial ecosystems, but they are neither, since wetlands are usually located at the interface between dry and permanently wet ecosystems. Because of their great variation in size and location, wetlands are difficult to define. The most notable features of wetlands are the presence of water close to the soil surface, unique types of soils,

and distinctive types of vegetation adapted to water saturated soils.

The importance of the functions of wetlands lies both in their traditional values as areas for wildlife protection and human usage, as well as their newly found values as areas for water management and conservation.

Wetland functions are closely linked to hydrology. There is general agreement, for example, that wetland basins which are not already filled to capacity with water will perform a flood attenuating function (see table 1). In other words, wetlands associated with streams and rivers will slow flood waters and reduce flood peaks. It has been shown that inland wetlands store water during floods and slowly release it to downstream areas, thereby regulating the duration of streamflow. There is also good evidence to show that many wetlands serve as groundwater discharge areas (plate 1).

Wetlands contribute substantially to improving water quality. In other words, those receiving water laden with an excess of substances such as nitrogen and phosphorus (nutrients) usually demonstrate high removal efficiencies. For this reason, some scientists refer to wetlands as 'nature's kidneys' for the functions they perform in hydrological and chemical cycles, and as the downstream receivers of wastes from both natural and human sources.

Through chemical and biological processes of various kinds, toxic substances such as some heavy metals

Instead of reclaiming wetlands for commercial use, they should be retained for their newfound values

Wetlands act as nature's kidneys, removing pollutants and improving water quality

Wetlands are among the most productive environments on earth, reducing flood waters and erosion

TABLE 1
The effect of wetland area on flood peak reduction
Percentages

Wetland in a watershed %	Storm recurrence interval (years)			
	2	25	50	100
1	19	22	26	27
2	28	33	38	39
3	34	39	45	46
5	42	48	54	55
10	51	58	63	64
15	56	63	70	71
30	64	71	77	79

and pesticides that are introduced into wetlands, can be changed to a harmless, non-toxic state. The vegetation associated with wetlands reduces the velocity of flood waters, and thereby controls erosion. Furthermore, the reduction in the velocity of flowing water as it enters or passes through, causes the release (or removal) of sediment being transported by the water (see figure 1).

accepted principle. Certain animals are completely dependent on wetlands for their life requirements, whilst others use them for only part of their lives. However, being located at the interface between dry and permanently wet environments, they are utilised by species from both aquatic and terrestrial ecosystems. This feature gives some wetlands the distinction of being among the most productive environments on earth.

Conservation

It is well known that wetlands provide habitat for a wide variety of plants and animals, and today, the maintenance of genetic diversity is an internationally

The rich diversity of waterbirds found in southern Africa (totalling about 130 species) owes its existence to the array of wetlands that are spread across the subcontinent. Being the southern termini

Plate 1: Wetlands play a crucial role in the alteration of surface run-off because of the extent to which they influence the infiltration and interception of rainfall

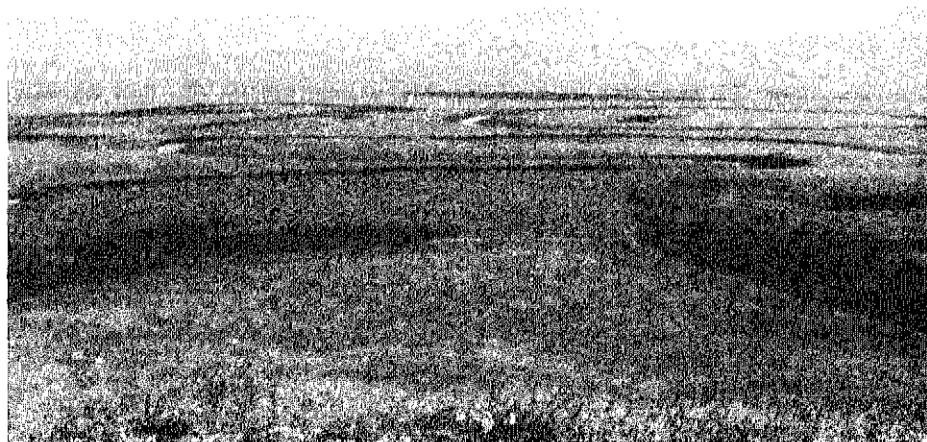




Plate 2: The harvesting of 260 tons of reeds each year from the Muzi swamps has led to the establishment of a thriving business in Maputoland

of many migratory species, these wetlands are also of international importance.

Many cultures in southern Africa have adapted to and benefited economically from wetlands. For example, they have been used for centuries as grazing for domestic stock, and for harvestable resources such as reeds (used for thatching and hut construction) - a traditional use encountered in many rural communities (plate 2).

It is also known that wetlands serve as recreation sites for fishing, hunting and observing wildlife, that they provide educational opportunities for scientific study, and that they provide open space for aesthetic enjoyment.

It should be understood that few wetlands perform all of these functions. Furthermore, because of differing biological and physical properties, not all perform all of the functions equally.

Economic Incentive

The extent of wetlands in South Africa is poorly known. However, what few studies have been conducted indicate that some dramatic changes have occurred over the last fifty years. For example, an estimated 58% of the wetlands in the 10 000 km² catchment of the Mfolozi river in Natal have been lost through natural erosion processes and a variety of

man-induced factors. Prior to 1970 wetland drainage and alteration were accepted practices, and even encouraged by certain agencies.

The functions and values of wetlands are only just being recognised in South Africa. Much needs to be accomplished before their attributes are translated into policy, regulations and management plans.

In South Africa, there is no yardstick available at present by which the 'goods and services' provided by wetlands can be reliably evaluated. In countries such as the United States of America however, considerable attention has been given to establishing the economic value of

Certain animals and waterbirds are completely dependent on wetland ecosystems

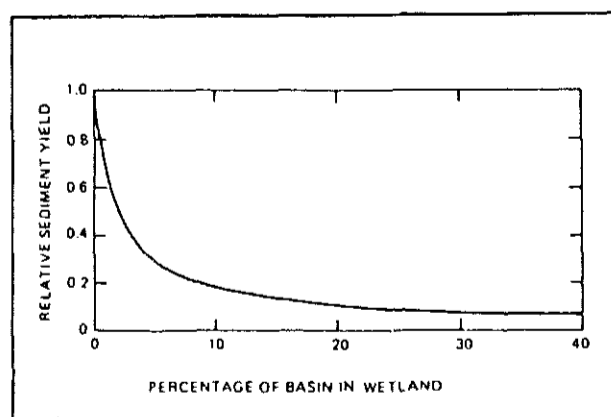


Figure 1: The type of relationship between sediment yield and the proportion of wetlands in a catchment

The public value of wetlands could be six times higher than the value for a developer wishing to drain it

wetlands. These initiatives have stemmed from the belief that there is nothing to be gained by economic development projects which produce only short-term advantages at the risk of long-term shortages.

A study of wetlands in Massachusetts, estimated their value at R368 000 *per hectare* (US\$147 000) as they have a high capacity for the provision of water supply, flood control, wildlife, recreational and aesthetic benefits. Another survey concluded that the public value of wetlands could be as much as *six times higher* than the value for a developer wishing to drain it.

No such statistics are available in South Africa. However, what is known is that by converting wetland to agriculture, the net farm income (in Rand/ha/year) can vary from as little as R100 (in the case of certain types of timber) to R570 (in the case of pasture production). Although these limited returns may be nonetheless important to the wetland owner, it is highly likely that their potential value to society could be many times greater.

Wetlands perform functions of flood protection, water storage and purification, and sediment removal at no cost to society

The commonly encountered attitude that wetlands are non-remunerative land appears ludicrous when it is considered that ever increasing sums of money are presently being spent throughout South Africa on flood protection, water storage, water purification and sediment removal. Wetlands naturally perform each of these functions *at no cost to society*. With the South Africa population expanding at an average rate of 2,7% per annum, the strain on the future water resources of this country (such as freshwater) means that man's dependence on wetlands is steadily increasing.

Solutions

Land-use changes on a large scale are characteristic of southern Africa. The development of large-scale agriculture, forestry and human settlements, accompanied by overgrazing and high human populations have resulted in markedly accelerated rates of erosion, industrialisation and urbanisation. These factors have, in turn, resulted in a marked deterioration in water quality and water yield. If improvement is to be effected, the conservation of wetlands as essential components of the rivers that drain the sub-continent will, therefore, for economic reasons, become imperative.

The only meaningful way in which wetland owners can be expected to respond strongly to the call for wetlands conservation, is through reward. Experience overseas has shown that where the utilisation of resources which result in substantial economic benefit to the public is involved, society as a whole must be prepared to pay for the benefits accruing from conservation efforts.

Thus a wide range of non-regulatory approaches to wetland conservation, including tax exemptions, servitude agreements and subsidies will have to be adopted. Such initiatives will complement the regulatory approach to wetland management, reduce the government's overall burden of responsibility, reduce the need for costly law enforcement, and develop a positive attitude amongst landowners to exercising the social responsibility of wetland conservation. **IPVA**

Environmental Strategies

WATER POLLUTION

THE DROWNING POOL

Dean Simpson,
Hydrology Researcher
Council for Scientific and Industrial Research

Our water resources are becoming more and more contaminated with pollutants derived from ever expanding urbanisation and industrialisation. Today industry produces some 70 000 different chemicals, many of which will inevitably find their way into water sources and supplies. These may be responsible for more than 50% of human cancer cases. According to World Health Organization statistics, about 50 000 people die every day as a consequence of using poor quality water and living in unsanitary conditions.

Durban is one of the fastest growing cities in the world. In 1988 there were an estimated 1,5m shack-dwellers in the Greater Durban Metropolitan Region (GDMR) area. With this great sprawl growing daily due to the population explosion and the influx of job-seekers from rural areas, the lack of proper sanitation and refuse removal facilities will no doubt add to local water pollution problems (see graph).

In the Mgeni catchment alone the requirement in 1985 will rise to a projected 2 000 megalitres per day in 2020, a massive threefold increase. By the year 2000 it is expected there will be more than 10m people living in the GDMR, all reliant upon this source. The question is - will there be enough clean water for all and at what cost? Only if forward planning takes into account projected changes in water quality and ameliorative measures are introduced to contain water pollution will there be any hope of sufficient water of an adequate quality for all user needs.

Diverse Sources

Water pollution is perceived in different ways by people in different disciplines. To the agricultural engineer it may mean an increase in dissolved solids in irrigation water, which may affect a crop; to the limnologist it represents increased concentrations of the plant nutrients nitrogen and phosphorus, which may give rise to unsightly algal blooms (eutrophication); to the aquaculturist it suggests the presence of toxic compounds to poison fish or prawns; while to the layman it could simply mean floating plastic debris or wind-driven foam.

Clearly, there are many facets to water pollution with diverse implications to the many water users. To gain a better understanding of the problem we need to take a look at the different sources of pollutants to water bodies.

Atmospheric fallout in the form of rain and dust are substantial sources of pollutants, particularly in built-up areas. Both gaseous and particulate air pollutants arise from numerous activities:

- Certain industries produce fluorides, phosphorus, and heavy metals;
- the combustion of fossil fuels results in sulphur and nitrogen oxides, hydrocarbons, and lead;
- the incineration of solid waste releases ammonia and trace elements; and
- land surface disturbances such as mining and construction emplace dust in the atmosphere. These pollutants may then be scrubbed from the air when rain falls.

Urbanisation and industrialisation are contaminating our water resources with more and more pollutants

Inadequate sanitation and refuse removal facilities in Durban's shack settlements are adding to water pollution

Data Base

Watching the Detectives

Various kinds of chemical or biological tests may be used in the laboratory or the field to detect and monitor water pollution:

• Oxygen Test

A common test is to measure the dissolved oxygen concentration in water bodies because there can be no life for fish and many aquatic organisms without oxygen. The solubility of oxygen in fresh water at a temperature of 20 degrees at sea level is 9,2 ppm. Any lower concentration than this may be an indication of pollution.

Dissolved oxygen in water is consumed by micro-organisms during their metabolism when suitable organic material is present, such as untreated industrial or sewage wastes. Fish become stressed at levels below 5 ppm of oxygen or at concentrations of ammonium and nitrite ions as low as 0,03 and 0,5 ppm respectively.

• Water Test

Another test of pollution is pH, a measure of acidity in water where pH 7,0 is neutral, and acidity increases tenfold for every unit below this value. 'Acid rain' with pH values in the region of 4, is mainly caused by the emission of sulphur dioxide during the burning of fossil fuels (see case studies in Part 2). It has been detected in many of our cities and in the eastern Transvaal where power-generating stations are sited. But the related problem of 'acid lakes' devoid of fish life (which has occurred in some parts of Europe and Canada) has not been a South African problem so far.

• Laboratory Test

Other detection methods include tests for a variety of metals and organic compounds using sophisticated laboratory instruments. But these methods are limited by the great number of 'potentially hazardous constituents' which may be present in water and the impracticality of testing for each of them.

• Biological Test

Biological tests for toxicity using suitably sensitive test organisms are also being used. For example, a culture of the water flea, *Daphnia pulex* may be exposed to an effluent for a period of time and the die-off rate of the flea measured. The fertilisation or non-fertilisation of sea urchin eggs is measured in marine water samples to detect toxicity. In this manner the collective toxicity of a number of compounds in effluents may be assessed.

Investigation of atmospheric fallout quality over a number of years in Pinetown revealed chloride and sulphate concentrations of 5 ppm, and metal concentrations ranging from 0,06 for lead to 1,2 ppm for iron, which is certainly far from pure water quality. On an areal basis, annual fallout rates of 200 kg of dissolved salts and 300 kg suspended solids per ha were measured. When rainfall meets the ground further contamination occurs from materials deposited by various catchment activities.

In the urban environment, street surfaces are major collection areas for wear and emission products of vehicles - zinc and cadmium from tyres, copper and asbestos from brake linings and hydrocarbons from motor oil. Exhaust gases from cars contain very fine particulates of the order of 0,01 mm in size, and about 50% of lead emissions form stable aerosols. It has been reported that, on average vehicles deposit 0,7 g of solids per axle-km travelled. A lot of these street surface contaminants are not removed by conventional cleaning methods such as sweeping because the particles are so small, and lodge in cracks and interstices. They are only removed by rainfall.

Decomposition of vegetation on impervious surfaces results in the release of phosphorus, nitrogen and organic compounds. Herbicides, pesticides and fertilizers (especially highly soluble nitrogen) can also be washed off lawns and gardens during heavy rainfall. The first flush of runoff from streets during a storm has commonly been compared in quality to that of raw sewage because of similar concentrations of suspended solids and oxygen-demanding substances.

All these are diffuse sources of water pollution, but there are also point sources, like treated sewage and industrial effluents. These discharges are controlled by uniform effluent standards so that most of the original organic load has been removed and the bacteria killed off by chlorination. Nevertheless, residual amounts of the plant nutrients nitrogen and phosphorus remain in treated sewage effluent and can cause excessive growth of algae and other aquatic plants in receiving waters.

Advanced treatment technology can remove almost any compound from

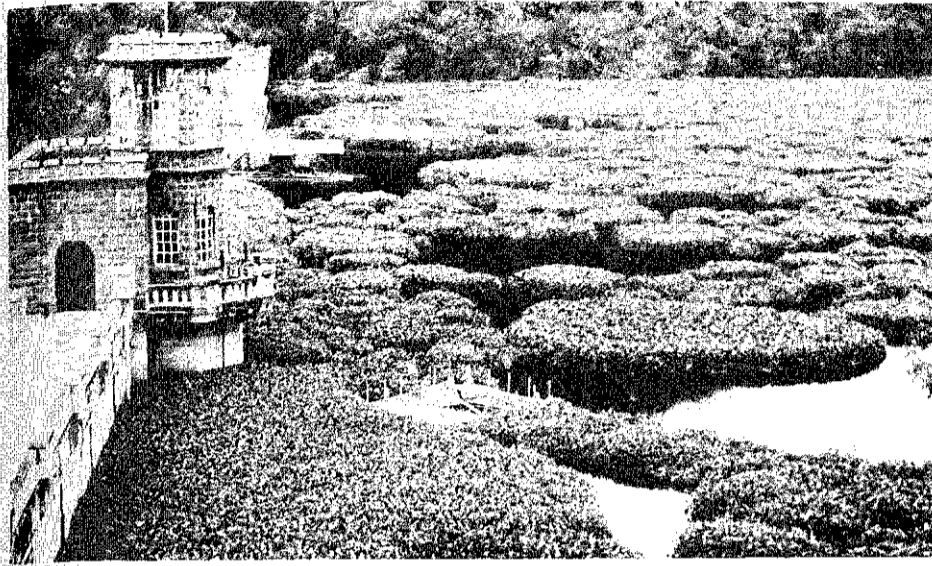


Plate 1: Noxious water Hyacinth on the Shongweni Dam outside Durban

water but the cost is high and, therefore, standards are set with this in mind. This philosophy is, however, changing to the setting of effluent standards based on the ability of the receiving water body to cope with the load and on down-stream user needs.

Water pollution manifests itself in the environment in many different ways. It may be seen as fish kills due to de-oxygenation - something that occurs periodically in the Isipingo river. It could be evident as eutrophication in dams, as is already apparent in the only just completed Inanda dam. It may be present as bacterial contamination of water courses posing a health hazard, as is the case with many of the streams in the Durban area. It might be indicated simply as siltation of dams and estuaries with associated economic implications.

High Costs

The price tag of treating the symptoms of water pollution can be high. For instance, clearing some 450 000 tons of water hyacinth from Shongweni dam cost R500 000 (plate 1).

Given the right conditions, this noxious plant can double in volume every 19 days. From a water treatment point of view the cost of producing potable water from Shongweni dam is nine times higher than that for treating Midmar dam water, due to the higher flocculent additions required and the need for removal of tastes and odours. Nagle dam also has increased water treatment costs, which double at certain times of the year.

Typically, tastes and odours in potable water arise from chemical reactions between certain organic compounds and chlorine during treatment. Phenols react to give chlorophenols which impart a medicinal taste, detectable at concentrations as low as two to eight parts per billion (ppb). Decay of certain algal cells may give rise to compounds such as 2 methylisoborneol and geosmin, a pesticide smell which is noticeable at the incredibly low concentration of 0,015 ppb, i.e., a concentration comparable to less than one person in the entire world population. Treatment for this type of problem usually involves the use of activated carbon or ozone.

Apart from the problem of chemical pollution to estuaries, there is a problem of siltation which results in loss of water depth and mouth closure on a semi-permanent basis. This state of affairs can occur as a natural phenomenon but in almost all cases is accelerated by various catchment activities such as inappropriate farming techniques (destruction of natural vegetation in waterways, overgrazing etc.). The degradation of estuaries in this manner has potentially serious ecological consequences as well as causing loss of recreational pursuits.

Of some 1 500 species of continental shelf fish, 81 species are either completely or partially dependent upon estuaries for their existence. These include the spotted grunter, the Natal stumpnose and the kob. Most species spawn at sea and the juveniles migrate into the estuaries where the rich food supply and the protection afforded from predators leads to rapid

Water pollution is manifested in many ways - bacterial contamination, dam siltation, dead rivers, blocked estuaries, etc

There is a high price tag for the effective treatment of the symptoms of water pollution

growth. After about a year they return to the sea where the cycle is repeated. Some fish are therefore dependent on open or periodically open estuary mouths. Encroachment and development on adjacent marshy areas (wetlands) which act as food sources and natural silt traps will also have an adverse impact on this resource.

There are not many local success stories to relate where pollution has been turned around and the water resource restored to a healthy state, but the Sezela lagoon on the south coast is one of them.

In 1979 degradation occurred as a result of untreated industrial effluent being discharged into the lagoon, described by Dr G Begg as 'a foul-smelling, filthy black cesspool'. In 1982 CSIR researchers found the bottom of the lagoon was covered by a black anoxic sludge, the water had a black appearance due to suspended metallic sulphide floc, and the dissolved oxygen concentration was close to zero. No living fauna was collected in trawls. A factor which contributed to the degraded state of the lagoon through a reduction in the fresh water supply was the raising of an upstream dam wall.

Fortunately, the management of a local sugar mill and a chemical plant did not like this state of affairs on their doorstep and a R1m effluent treatment plant was installed to stabilise the organic load.

Subsequently, through careful management by artificially breaching the mouth to get rid of anoxic water and bottom deposits, the lagoon has come back to life. Recovery has been seen in improved oxygen levels, the re-emergence of an aquatic faunal community including 14 fish species, and prawns which are particularly sensitive to pollution as they live on fish eggs and mud deposits.

Pollution Survey

The CSIR is presently engaged in research to characterise land-use/water quality effects from a number of catchments in the Durban area with distinctive land-uses. Analysis of the data collected so far have clearly shown up the different pollution potential of types of land-use.

The dense formal and informal (squatter) residential areas (plate 2) produced the highest concentrations of suspended solids, turbidity and the plant nutrients, while the catchments with substantial amounts of industry in them had the highest levels of organic pollution. Runoff from all showed significant faecal bacterial contamination but the highest levels of up to 1m coliforms per 100 ml emanated from the informal settlement areas.

A CSIR survey shows that squatting without proper services poses a great danger to water resources

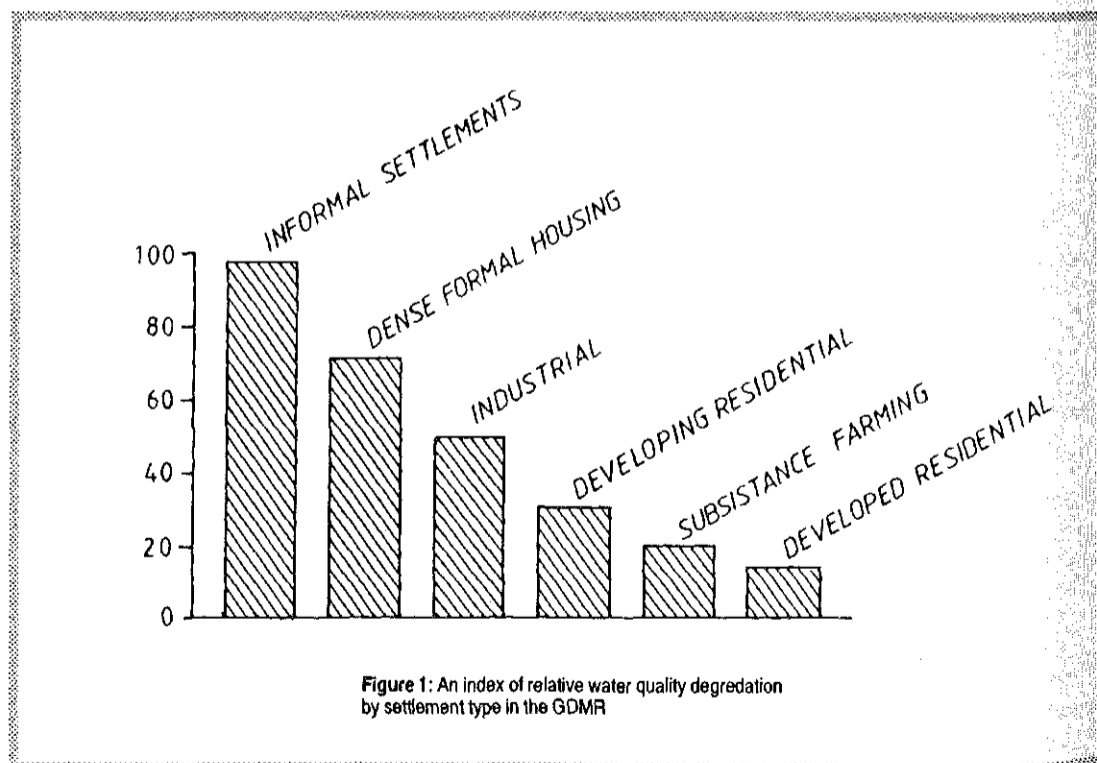




Plate 2: High levels of water pollution are found in the dense informal settlements surrounding Durban

When one considers that for recreational waters a maximum limit of only 200 faecal coliforms per 100 ml is recommended, and the standard is zero for drinking water, then the threat that this type of land-use - squatting without proper services - poses to water resources is very clear.

To give a general comparison of water quality from the different land-uses, the mean concentration for each test conducted (suspended solids, turbidity, phosphorus, dissolved salts, organic carbon and bacterial contamination) was ranked between sites and then summed to give a relative water quality degradation index, which is given in the accompanying figure.

As already stated, by far the poorest quality came from the densely populated squatter areas and dense formal housing, followed by the catchment with industry. Then came the catchment undergoing development with the established residential area showing the best quality of runoff, due no doubt to the large size of the properties, commonly 0,3 ha or more, the lesser disturbance and the ability of natural areas to soak up pollution. Runoff quality from the rural catchment with subsistence farming was poor mainly because of high turbidity at times due most probably to farming practices.

Solutions

In conclusion, a few thoughts need to be expressed on methods to control water pollution. Point sources, that is effluents discharged from pipes, are relatively simple to control through the setting of discharge standards which can be maintained by law enforcement. If need be an effluent can be treated to a high

standard because modern technology has most of the answers, albeit at a high cost.

Control of diffuse sources is much more difficult because it is ubiquitous in nature. Nevertheless, there are certain strategies that can be pursued to contain the problem.

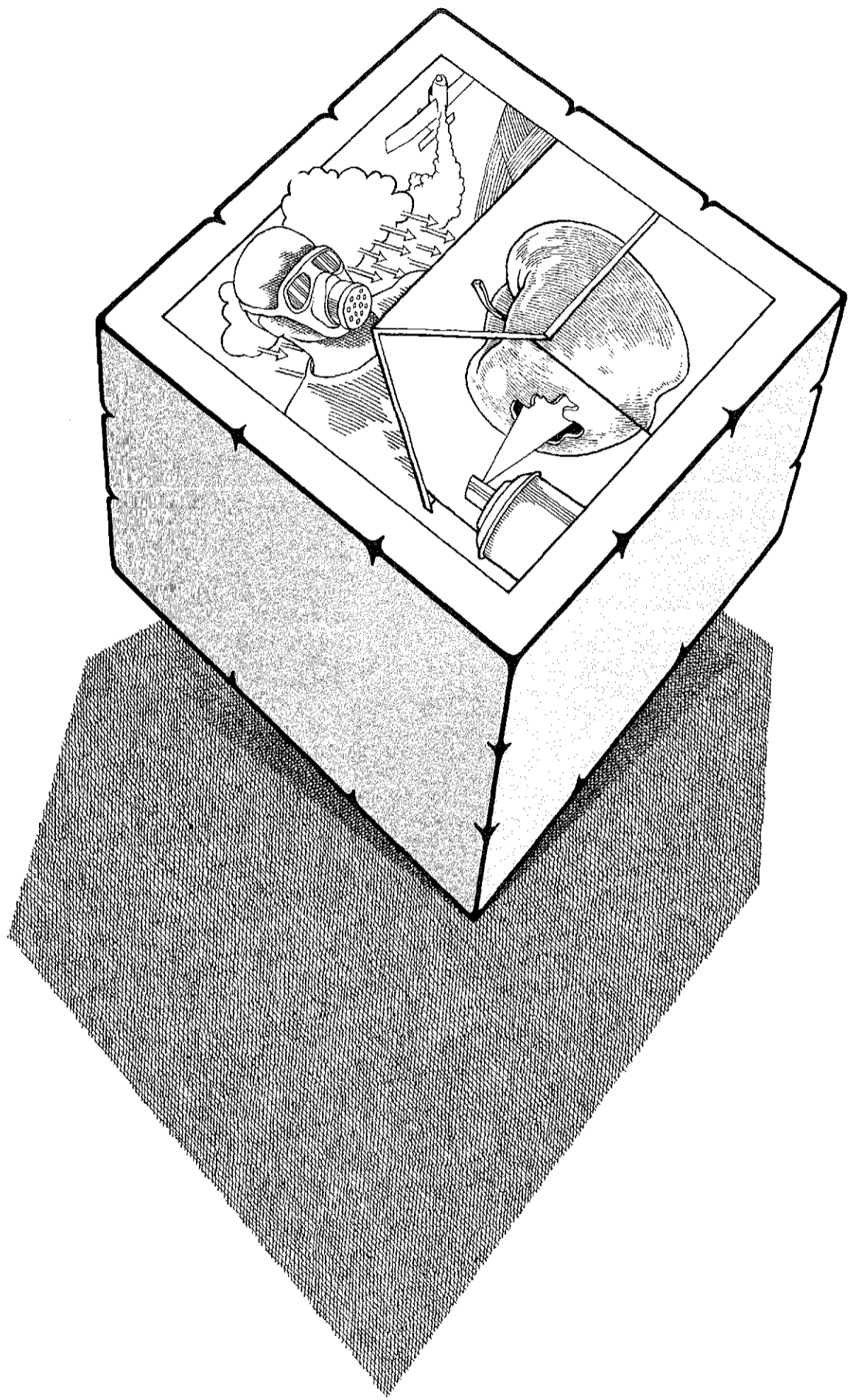
Clean water for personal use and waste disposal facilities must be supplied to the squatter sprawl surrounding our cities. There must also be education of the masses towards environmental protection. Stormwater runoff pollution from impervious surfaces such as streets and roofs can be controlled with an urban development plan to include measures such as:

- the use of porous paving with maximum infiltration to reduce runoff volume;
- diversion of the first flush containing high concentrations of pollutants for treatment;
- the use of retention ponds to settle out solids and improve quality;
- and improved street cleaning methods.

In rural areas green belts about water courses instead of farming to the banks of rivers would go a long way to reducing soil erosion and pollution from absorbed chemicals. Similarly, grassed waterways, contour ploughing and not overloading the carrying capacity of the land for grazing animals are also effective methods in reducing pollution.

Continued research into identifying and assessing pollution problems is vital for the maintenance of our water resources. Public awareness and concern is also essential to sustain the pressure on policy makers to always take into account the effects on the water environment when making decisions on development. **UPWA**

Public awareness is essential to sustain pressure on policy-makers to balance development with clean water needs



Part 2 Overview

THE AIR WE BREATHE

Astronauts have remarked on the beauty of the thin layer of air that envelopes the earth, providing all the benefits which we associate with our atmosphere. This thin fragile mixture of gases, with its life-supporting attributes, is often compared to the skin of an apple.

The thinness of the atmosphere is largely due to the compressibility of air under the earth's gravitational influence. One-half of the air in the atmosphere lies below 6 000m (twice the height above sea level of the Natal Drakensberg); three-quarters below 11 000m.

The atmosphere is part of the commons which means that it is publicly, rather than privately owned. As a result it has been used by man as a dump for gaseous wastes for thousands of years. However, the nature and the concentration of various pollutants is now causing serious impacts on the environment. At a local level acid rain and hormone herbicides are causing growing concern in Natal: on a global scale the ozone hole and the greenhouse effect is causing governments to debate the issues with the object of taking collective action.

Because the atmosphere is part of the commons the solution to problems of air pollution can only be addressed by governments. The search for solutions can be traced back many years. At present many governments rely on air pollution legislation assisted by technological developments. However, in the United States progress has also been made with the introduction of economic incentives.

There will always be some pollution. The goal of environmental managers is to minimise the pollution and the resulting impacts. This requires an understanding of both natural and social systems. In this section we look at the management of air as a precious natural resource:

- Two of the case studies describe the nature of impacts caused by pollutants (herbicide and ozone problems) and what can be done about it.*
- Another case study describes climatic characteristics relevant to air pollution over Natal and outlines some of the features that need to be considered by decision-makers concerned with air quality.*
- The concluding article describes some environmental management strategies, examines the nature of air quality strategies in the United States and makes recommendations for amendment to the South African Air Pollution Prevention Act 45 of 1965.*

Case Study 1

WHERE HAS ALL THE OZONE GONE?

Professor Roseanne Diab
Department of Geographical and Environmental Sciences
University of Natal

The ozone issue is currently the focus of much media attention in South Africa, where we find ourselves in the position of a frontline state in the battle against the ever expanding 'ozone hole' over Antarctica.

What exactly is the 'hole'? It is a phenomenon created by the dramatic decline in total ozone over Antarctica to below half the normal concentration. The trend was first detected by Joe Farmon and his team at British Antarctic Survey, who had long been monitoring total ozone above their Antarctic base of Halley Bay. Since 1979 they had noted a mysterious fall each spring. Initially, they were reluctant to release their findings since the NASA satellites had failed to identify a similar trend, but by 1985 they decided to publish their findings in what has now become a classic paper (Farmon et al, 1985).

NASA scientists raced to re-examine their global satellite data set and discovered that their computers had in fact been programmed to ignore ozone values

below a certain limit as being erroneous. Such low values were thought to be impossible! Upon re-examination they found that, indeed, they could confirm Farmon's findings and give a spatial perspective to what was now becoming known as the 'ozone hole'.

Alarming, the ozone hole has been deepening and increasing in horizontal extent with each subsequent year, so that it is now larger than the size of the continental United States and steadily encroaching into subpolar latitudes (See ozone maps: inside front cover). What is less well known is the somewhat less than dramatic decline in ozone levels over the remainder of the globe. For example, it is estimated that since 1978 ozone has declined by 1% per annum in the latitude zone 30° to 40°S. Nearly half of South Africa is incorporated within this latitudinal zone (see figure 1).

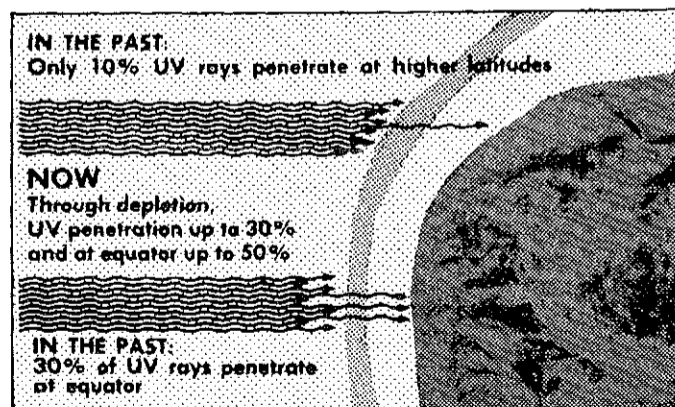
Evidently, a global trend has been magnified in Antarctica because of its unique meteorological conditions caused by the polar vortex. This is a swirling

The ozone hole is larger than the size of the continental United States and encroaching into sub-polar latitudes

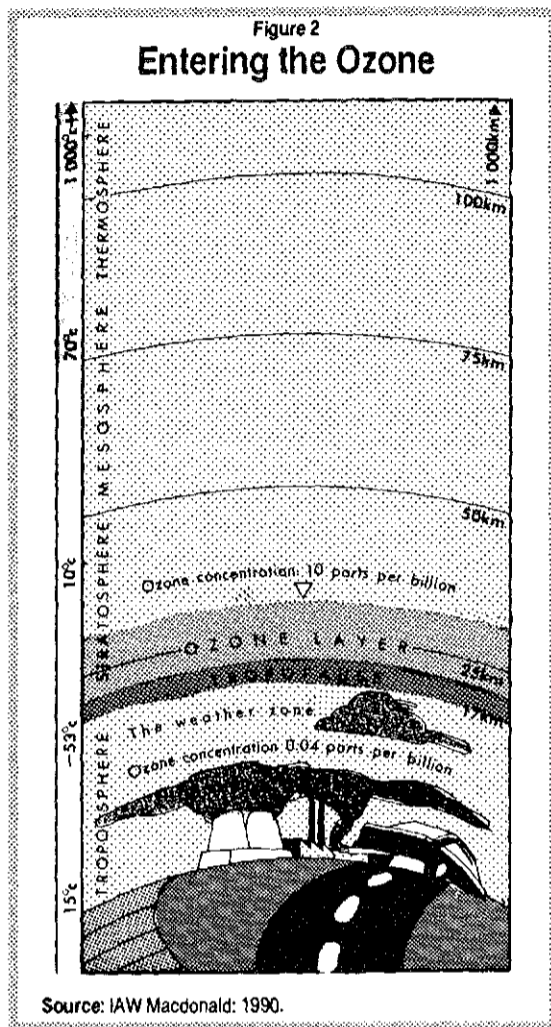
The role of ozone is to provide the earth with an effective shield against damaging ultra-violet rays

Figure 1: Ozone depletion and ultraviolet radiation increase

Source: IAW Macdonald, Fitzpatrick Institute, University of Cape Town. The Daily News/BP Ozone Fact File: 1990.



A single chlorine atom released by CFC's may destroy more than 100 000 ozone molecules in the stratosphere



reaction vessel which speeds up the rate of ozone destruction.

Ozone (O_3) is similar in structure to the oxygen that we breathe except that it consists of three rather than two atoms of oxygen. It is present throughout the atmosphere but is concentrated in a layer within the stratosphere between 20 and 25 km (see figure 2). This is the layer which is vulnerable to depletion and which is so important for our continued existence on earth.

The role of ozone in the stratosphere is quite simple. It is to absorb most of the Ultra-Violet-B radiation from the sun, thus providing the earth with an effective shield against these potentially damaging rays. Over-exposure to Ultra-Violet-B radiation will:

- destroy the particularly sensitive organisms such as plankton in the oceans and so disrupt the marine food chains;
- increase the incidence of skin cancer and eye cataracts amongst humans. A United States Environmental Protection Agency (EPA) report estimates that for every 1% reduction in ozone there will be a corresponding increase in skin cancer incidence of 1-3% and an increase of 0,8 to 1,5% in melanoma cancer mortality rate;
- lead to a change in the circulation patterns in the stratosphere and impact upon our weather in an as yet undetermined manner.

Over-exposure to ultraviolet radiation will destroy sensitive organisms, change the weather and increase skin cancer

mass of strong westerly winds which encircle the pole and seal off the cold polar air from the warmer air in lower latitudes during the long cold polar winter. This creates a self-contained

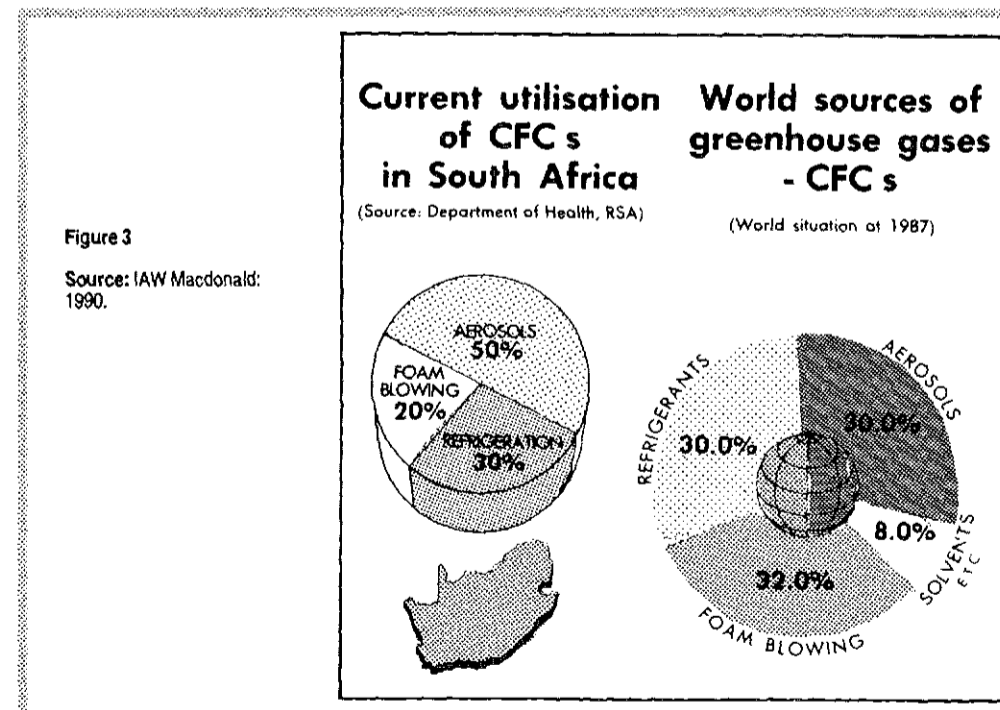
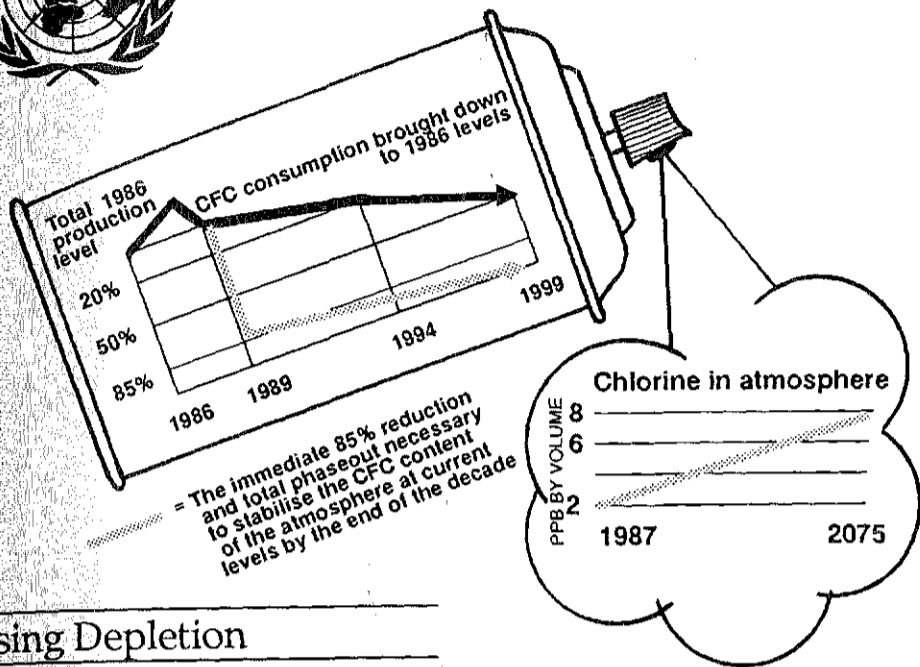




Figure 4

The Montreal Protocol on substances depleting the ozone layer



The Montreal protocol on freezing CFC production is the first international agreement to protect the earth's atmosphere

The Helsinki agreement calls for a more rapid phasing out of CFC's to halt the destruction of the ozone layer

Causing Depletion

Mankind stands accused! It is quite unequivocally our widespread usage of chemical compounds such as CFC's (chlorofluorocarbons) (see figure 3) and halons which are responsible for the formation of the ozone hole. In the past CFC's have been regarded as such innocuous compounds that they have been widely used as propellants in aerosol spray cans, coolants in refrigerators and air conditioners, as solvents for cleaning circuit boards in the electronics industry and in the manufacture of foam products.

Ironically, it is their stability and non-toxicity close to the surface which is the root of the stratospheric ozone depletion problem. CFC's are stable until they penetrate the stratosphere, where they are exposed to ultraviolet (UV) radiation from the sun. Here they break down, releasing the free atom of chlorine, which then acts as a catalyst, speeding up the normal process of conversion of ozone to oxygen. The ozone-oxygen balance in the stratosphere is upset and effectively, ozone levels decline.

Moreover, to exacerbate matters, the chlorine atom is not satisfied with the destruction of one ozone molecule, for after it has annihilated its first target it is freed to continue with its destruction. In fact a single chlorine atom may destroy more than 100 000 ozone molecules before it becomes inactive.

Recently, it was discovered that the ozone depletion potential of halons is up to ten times greater than CFC's, the

catalyst in this case being bromine (Br) rather than chlorine. Halons are used extensively in the fire protection industry, and so a large pool of halons is stored in fire extinguishers awaiting future release.

Montreal Protocol

The discovery of the potentially disastrous effects of these chemical compounds leads naturally to an examination of what is being done to avoid the acceleration of ozone depletion. In this respect the most significant development was the Montreal Protocol of September 1987. It has been hailed as a major diplomatic breakthrough and is the first international agreement of its kind aimed at the protection of the earth's atmosphere.

The protocol calls for all industrial nations to freeze CFC production at 1986 levels, followed by a 50% reduction by the end of the century (see figure 4). Halon production is to be frozen in the mid-nineties. Third World countries are able to continue increasing their usage of halons and CFC's for a further 10 years, and producing countries will be able to expand their production to meet these needs. The Soviet Union also received a special growth dispensation.

South African industry is committed to phasing out CFC production and is actively involved in the search for alternatives

The search for alternatives to CFC's in air conditioning and refrigeration continues

After the required two-thirds of consuming nations had ratified the Montreal accord, it came into effect on 1 January 1989. South Africa, although not one of the participating nations in Montreal, has become a signatory to the agreement.

Whilst the Montreal Protocol is welcomed, it is felt that it has come too late and that it does not go far enough. The agreement comes more than thirteen years after it was first discovered that CFC's posed a threat to the ozone layer. Industry has been slow to concede the damaging effects of CFC's. It was only after the United States company, du Pont, a major world producer of CFC's, acknowledged that it was economics rather than chemistry, which was preventing them from developing alternatives, that the stage was set to phase out world production of CFC's. The problem is slightly more serious with regard to halons for alternatives have not yet been proven.

Unfortunately, the Montreal Protocol will not halt destruction of the ozone layer but will merely prevent the acceleration of depletion. Recent results from scientific investigations of the ozone hole have prompted some nations to press for more stringent controls. Several meetings were held in Helsinki during 1989 to review the control measures and culminated in the Helsinki Agreement, which calls for a more rapid phasing out period. It is expected to come into effect later this year.


Solutions

Acceptance of environmental responsibility by industry is the first step towards saving the ozone layer. For the most part industry has exhibited a very

positive attitude towards the changes which are necessary. The only producer of CFC's in South Africa, AECI, is committed to phasing out CFC production and is actively involved in the search for alternatives.

The Aerosol Manufacturers' Association of South Africa believes that towards the end of 1990 most aerosol spray cans, with the exception of a few specialist medical products such as asthma sprays, will be free of CFC's (see case study in Part V). The search for alternatives in the air conditioning and refrigeration sectors continues.

A second step is education of the South African public about the importance of the ozone layer and the vital consumer role that we can each play in preventing further accelerated depletion. In this respect the Wildlife Society of South Africa has made a worthy contribution through their nationwide Ozone Awareness Campaign and the launch of their ozone friendly stickers for consumer products.

Side by side with these developments should be a strong emphasis on scientific research aimed at finding alternatives to CFC's and halons, and aimed at monitoring the status of ozone and ultraviolet levels, to determine what changes have taken place and the underlying reasons for these changes. 

References

Farman, JC, BG Gardiner and JD Shanklin. Large losses of total ozone in Antarctica reveal seasonal Cl_x/NO_x interaction. *Nature*, 315/207-210: 1985.

Case Study 2

ILL WINDS IN NATAL

Professor Rob Preston-Whyte

Department of Geographical and Environmental Sciences
University of Natal

The atmosphere has long been regarded as a convenient repository for the emission of pollutants from urban areas, industrial sites and transport systems. When released into the atmosphere, these pollutants are diffused by turbulent mixing and transported by winds. An air pollution problem arises when these dumped wastes exceed the natural cleansing ability of the atmosphere and accumulate in the air near the surface in concentrations likely to cause damage. These concentrations do not remain constant but fluctuate from day to day, and at different times of the day, due to changes in the ability of the atmosphere to dilute pollution by mixing.

The mixing ability of the atmosphere is determined by its stability. In Natal, the topography adds an additional complication since it causes the development of wind systems that may transport pollutants over considerable distances. The intention of this article is to show that, because of the nature of the topography and atmospheric environment over Natal, special care must be directed to the control of atmospheric pollutants. Decision-makers concerned with air quality in Natal must

be alert to the nature of the control exerted by two factors: vertical mixing in the atmosphere by turbulence and the horizontal transport of pollutants by winds. The manner in which these two factors interact over Natal is described below.

Turbulent Mixing

The extent to which pollution can be dispersed vertically depends upon the *stability* of the atmosphere. A stable atmosphere is one which suppresses turbulence and, therefore, limits the vertical diffusion of pollutants. An unstable atmosphere is strongly turbulent and, therefore, facilitates diffusion of pollutants by vigorous vertical mixing.

The most extreme form of atmospheric stability occurs when the air temperature increases with height through a specific layer. This is known as an *inversion* condition. Pollutants emitted in such conditions will not disperse upwards but may be carried horizontally by light winds (see figure 1). Plumes from industrial stacks on winter mornings usually exhibit this characteristic.

The atmosphere and topography of Natal means that special care must be taken to control pollution

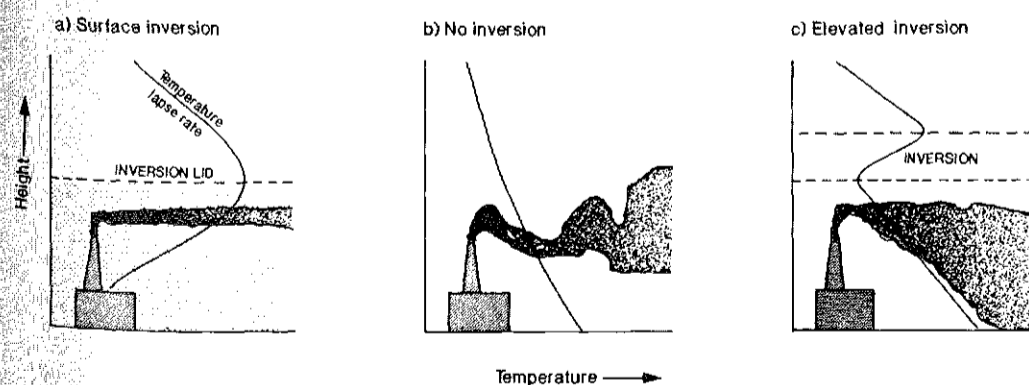


Figure 1: The form of plumes emitted from industrial stacks under (a) stable (inversion) atmospheric conditions near the surface, (b) unstable conditions near the surface and (c) unstable conditions near the surface but stable (inversion) conditions above.

Pollutants are mixed vertically by turbulence within the Natal airshed and transported by winds

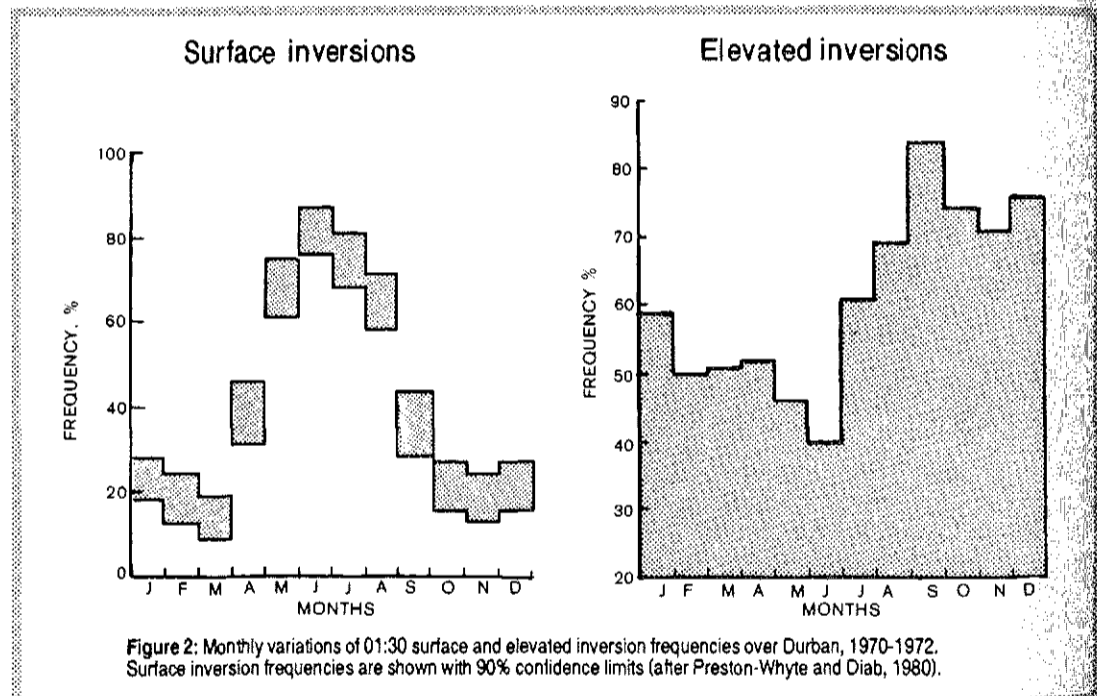
Two types of inversions commonly occur over Natal. The first extends from the surface upwards and forms at night under cloudless, calm conditions through radiational cooling of air near the ground. The second occurs above the earth's surface and is usually caused by the warming effect of subsiding air.

Surface inversions over Durban occur with a frequency exceeding 70% from May to August while elevated inversions occur with a frequency exceeding 70% from August to December (see figure 2). The important difference between these two inversion types is that, while surface inversions are eroded after sunrise by surface heating and turbulence and subsequently disappear, elevated inversions may persist for days and extend over vast areas.

Pollution Transport

Not only are pollutants mixed vertically by turbulent mixing within the airshed but they are also transported by winds which are induced by the topography. These winds develop when pressure gradients, caused by temperature changes in river valleys, drive air upslope and upvalley by day and downslope and downvalley by night.

The most efficient transporters of pollution are the nocturnal downslope and downvalley winds. These winds occur under stable atmospheric conditions and tend to fill the valleys with cold air. When this occurs the cold air tries to overflow the ridges into the adjacent river valleys but fails because they too have filled with cold air. The



Rain washes pollutants out of the air, causing extensive damage to building surfaces, clothing and plants

Elevated inversions occur under fine weather conditions such as when an anticyclone is located over South Africa. These systems are deep, associated with sinking, warming air and occur throughout the year but most frequently from July to December. The base of elevated inversions occur at about 1 500m over Natal and extend inland from the coast to transect the Natal Escarpment (see figure 3). This bounded space may be regarded as a vast coastal airshed open only to the sea. Pollutants emitted into this airshed will be retained for as long as the inversion persists. Inhabitants of Natal are familiar with the smoke haze during the veldfire burning period.

result is a deepening layer of cold air which extends from ridge-level upwards.

Bearing in mind that the Natal topography is deeply dissected by rivers trending northwest-southeast and that local relief exceeding 500m is not uncommon, it is not difficult to visualise the nocturnal seaward flow of cold air in the river valleys, known as mountain winds, with a similar seaward flow of air above, known as the mountain-plain wind (see figure 4). These winds merge with offshore land breezes near the coast. By day, the onshore sea breeze merges with topographically-induced winds which reverse to blow upslope and

upvalley. Therefore, under fine weather conditions it is common to find local and regional winds following a type of diurnal tidal motion within the Natal airshed, blowing from the Drakensberg towards the coast by night and reversing by day.

Pollution Deposit

Pollution damage occurs in a variety of ways. Wet deposition occurs when pollutants are washed out of the air by rainfall. This causes damage to building surfaces, clothing and plants. Dry deposition occurs when pollutants attach to surfaces after being brought to the surface. How these forms of deposition occur in the Natal airshed are worth examination.

The manner in which pollutants reach the ground is influenced by atmospheric stability conditions and the degree of turbulence in the air. These conditions can be observed by watching changes in the form of plumes from industrial stacks.

In a stable (inversion) environment vertical motion is suppressed and the plume remains thin (see figure 1a). Viewed from above it may appear to have a fan shape or it may form a straight or meandering ribbon plume. Such plumes commonly occur at night under clear, low wind conditions. The greatest

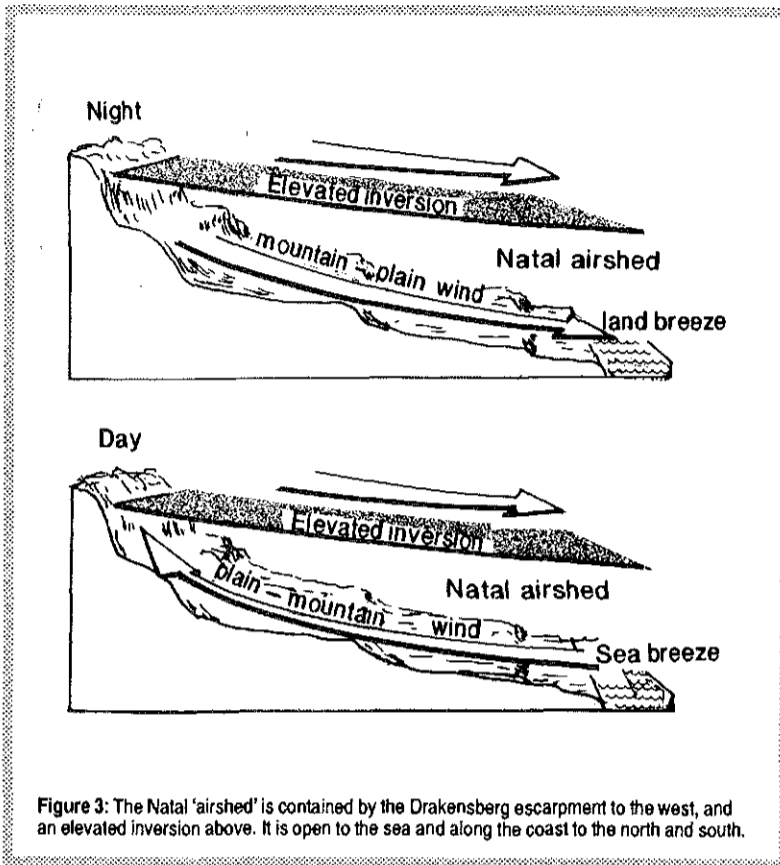


Figure 3: The Natal 'airshed' is contained by the Drakensberg escarpment to the west, and an elevated inversion above. It is open to the sea and along the coast to the north and south.

amount of mixing occurs when large convection eddies in an unstable environment carry the plume up and down with increasingly large sinuous loops (see figure 1b). In the presence of a stable layer aloft, plumes are prevented from growing upwards and instead disperse towards the surface. This is

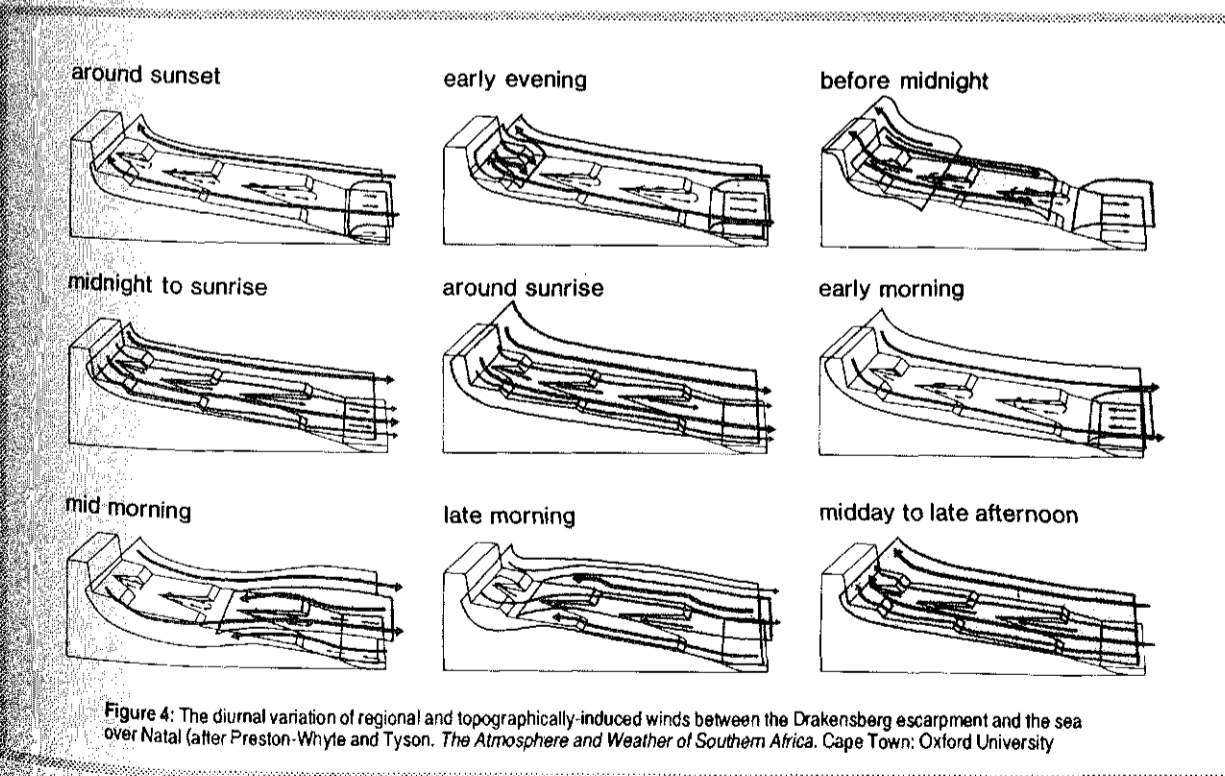


Figure 4: The diurnal variation of regional and topographically-induced winds between the Drakensberg escarpment and the sea over Natal (after Preston-Whyte and Tyson. *The Atmosphere and Weather of Southern Africa*. Cape Town: Oxford University)

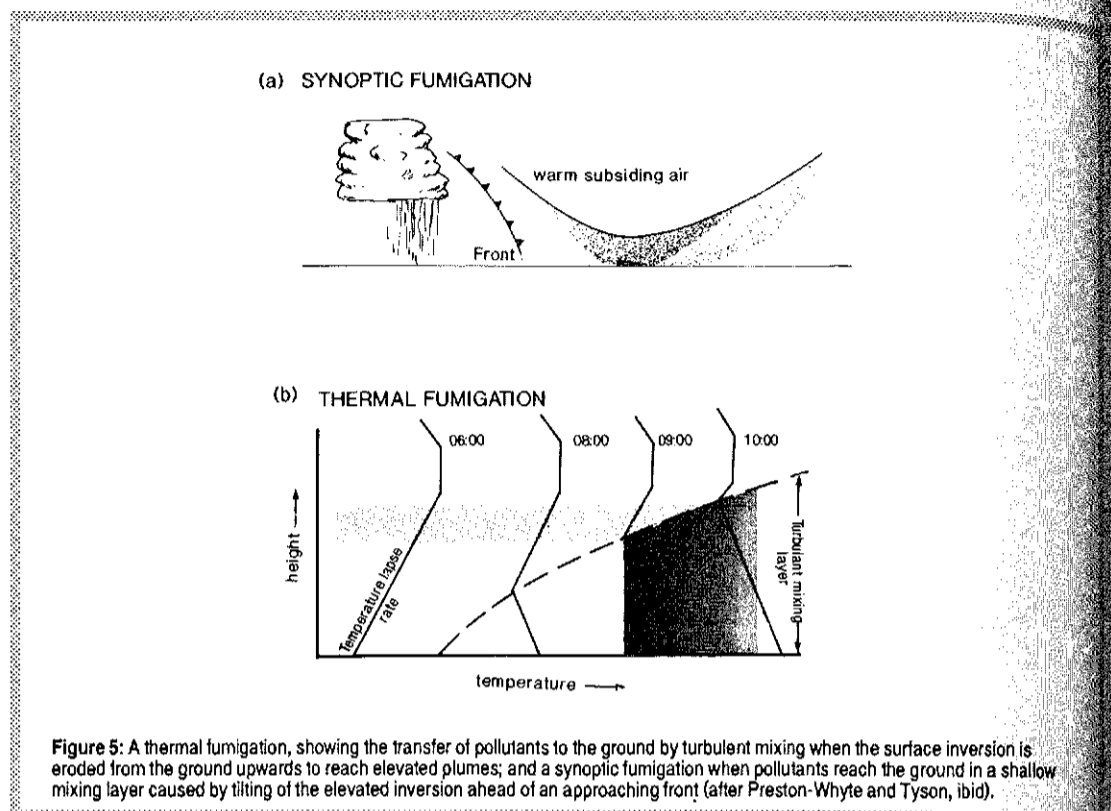


Figure 5: A thermal fumigation, showing the transfer of pollutants to the ground by turbulent mixing when the surface inversion is eroded from the ground upwards to reach elevated plumes; and a synoptic fumigation when pollutants reach the ground in a shallow mixing layer caused by tilting of the elevated inversion ahead of an approaching front (after Preston-Whyte and Tyson, *ibid*).

High pollution concentrations are brought to the surface by fumigations, another special feature of the Natal airshed

called a fumigation condition and is often responsible for dry deposition of pollutants at the surface (see figure 1c).

Fumigations occur in various ways in Natal. Synoptic fumigations occur over Natal in association with the passage of low pressure systems along the coast. Many of these lows are shallow coastal phenomena with the pressure minima located beneath a wedge of warm subsided air and its associated elevated inversion (See figure 5a). The approach of the low is associated with a reduction in the height of the elevated inversion which reaches its lowest level immediately before the arrival of the coastal low front.

Atmospheric ventilation is severely restricted under these conditions, with dry deposition of pollution occurring at the surface. With the passage of the pressure minimum, strong southwesterly winds in an unstable atmosphere eliminate the low-level stable layer and allow the pollution to be diffused through a deeper mixing layer. Rainfall may follow in the wake of the low, causing wet deposition of the pollution.

The contents of a fanning plume may be carried to the surface by a thermal fumigation (see figure 5b). This occurs

when a surface inversion is eroded by surface heating. When the turbulent mixing layer reaches the plume level, the contents of the plume are brought to the ground leading to high ground level concentrations for a short period of time (15-30 minutes). This phenomenon was recognised some 43 years ago when it explained the mysterious blighting of crops some 55 km downwind of a steel smelter in the Columbia River valley in Canada.

Predictions

The prediction of what will happen to pollution when once it is released into the atmosphere relies, therefore, on knowledge of the complex and individual nature of local climate and weather. This is particularly true in Natal where the topography and nature of the coastal weather systems leads to conditions in which pollution accumulates and is transported within the Natal airshed. The manner in which high pollution concentrations are brought to the surface by fumigations is also a feature of the air pollution meteorology of the province and its recognition may require specialist knowledge of local conditions. **IPWA**

Case Study 3

JEKYLL-AND-HYDE HERBICIDES

Mark Laing
Department of Plant Pathology
University of Natal

Since their development at the end of the Second World War, herbicides have come to play a vital role in agricultural production systems, together with fungicides, insecticides, growth regulators and other agrochemicals. With the shortage of rural labour arising from urbanisation, and in the future from AIDS, there is no possibility of returning to 'the good-old-days' of manual weeding. However, the use of herbicides in solving one set of problems may create another.

The current issue raised about hormone herbicides in South Africa reflects a subset of a greater debate: the conflict of interests which may arise from the use of agrochemicals, and the inadequacy of our current society to deal with such conflicts of interests in a constructive, objective manner.

Ever since their introduction, and all over the world, the drift of hormone herbicides (both local and long distance) onto off-target areas has caused serious damage to susceptible vegetable and fruit crops (ironically, they are heavy users of agrochemicals themselves). In the UK today this is the major cause of litigation between farmers and their neighbours.

In areas of the USA and Europe where mixed cereal/broad-leaved crops are grown in close proximity, there are extremely severe restrictions on the use of hormone herbicides. In Florida, the Florida Rules were promulgated to solve this problem, which restrict the application of hormones to such an extent that drift incidents have been reduced drastically. A big difference between South Africa and the USA is that they have the infrastructure to implement and enforce such rules; currently we do not,

having only one inspector for the whole of Natal.

There have been hormone herbicides court cases in South Africa dating back to the 1960s. In recent years (since 1985) damage to vegetable and fruit crops have been observed all over Natal, the Transvaal, the Free State and the Cape. In Natal, in the Tala Valley alone in the last two years, damage has been quantified at many millions of rands. But it must be stressed that this is *not* just a Tala Valley problem: this problem occurs throughout the province, and it is an artificial perception, created by the press, that the hormone herbicides problem is localised to the Tala Valley.

Government researchers have recently analysed rain samples from all over Natal, and have found 33-100% of samples from the different sites contained 2,4-D and other hormone herbicides. Similar results have been obtained by University of Natal researchers using different analytical techniques: the majority of rain samples assayed from various parts of Natal were positive for one or more hormone herbicides.

Another indication of the widespread incidence of hormone herbicides in South Africa is that in visits to the municipal markets in Durban or Pietermaritzburg, it has often been difficult to find any tomatoes or lettuce on sale from anywhere in South Africa which do not display typical, textbook symptoms of hormone herbicide damage.

At low doses, hormone herbicides do not kill susceptible plants but cause a wide range of abnormal growth responses. The crucial question then arises as to what levels of hormone herbicides applied

The drift of hormone herbicides onto off-target areas causes serious damage to susceptible vegetable and fruit crops

It is difficult to find tomatoes or lettuce on sale from anywhere in South Africa which do not display typical symptoms of herbicide damage

Data Base

AGRO-CHEMICALS AND THE ENVIRONMENT

The hormone herbicides are a group of chemicals which kill weeds in a similar way, by functioning as analogues of the natural plant hormone, auxin (as artificial steroids are to athletes). Examples are the chemicals 2,4-D, 2,4,5-T, MCPA, dicamba, triclopyr and picloram. These chemicals are sold under their chemical names or with trade names such as Actril[®], Garlon[®] and Turfweeder[®].

Because they act as a long-lived hormone, they can destabilise normal plant growth, even in minute concentrations: recent research by a South African at Bristol University has shown that as little as 1 gram of 2,4-D evenly diluted in 3 million million litres of air will cause damage to tomatoes and lettuce if these are exposed for as little as 12 hours. A way to visualise this is to think of driving Durban to Johannesburg and back 2 500 times; then, wearily, you get out of your car and measure *one millimetre* of the overall trip; that is an equivalent level of significance: 1/3000 000 000 000.

First discovered in 1944, they are cheap, effective on a wide spectrum of broadleaved weeds and have a short to medium lifespan in the soil or water systems (i.e., no residue problems). They are also extremely selective, killing weeds in grass crops, without damaging the crop much (except at some stages). They are popular with the world's farmers of sugar cane, maize, wheat, pastures, turf and timber.

There are numerous alternatives to the hormone herbicides so their disappearance from the market would not disrupt agriculture unduly but it could increase the cost of production of some crops, by a small proportion of the total costs of production. In some cases in Natal, sugar cane farmers have dropped 2,4-D from their herbicide programme, actually *reducing* costs, and with no loss of weed control.

The pure products are considered to be relatively safe to mammals, the small molecules being eliminated by the kidneys quite soon after animals absorb them. Numerous studies and reviews have found 2,4-D to be a safe agrochemical with respect to the hazard it poses to human health. There is some research showing that farmers using these herbicides regularly have a higher incidence of a particular type of cancer, but this research has been criticised by independent and authoritative researchers.

A different problem may occur when contaminants are produced as a part of the manufacturing process and are not eliminated from the final product, which is a costly process. The controversy surrounding the hormone herbicides 2,4,5-T, and the 2,4-D and 2,4,5-T (50% each) defoliant mixture called Agent Orange which was widely used in Vietnam, arose from a dangerous contaminant of the 2,4,5-T, a dioxin called TCDD, and *not* from the herbicide itself: 2,4-D synthesis does not generate TCDD.

A most significant, but poorly understood point should be noted. The levels of hormone herbicides needed to cause immediate damage to mammals are many millions of millions of times higher than those which cause damage to susceptible plants; i.e., the level that will cause severe damage to a lettuce will be totally innocuous to a human. In other words, hormone herbicides-affected vegetables can be eaten without fear, their poor quality, taste, plant disease and poor keeping-quality aside.

under a variety of conditions will cause economically significant damage to a variety of crops. Preliminary research by Mr Kevin Lovell (Dept of Plant Pathology, University of Natal) shows that as little as 400 millionth millionths of a gram per litre of air 2,4-D applied to lettuce for 6 hours causes a 30% loss of production, the plants showing no long-term symptoms. So vegetable crops showing symptoms can be expected to suffer greater losses than these.

The net result to the vegetable farmer is a loss of crop yield, quality and shelf life, and an increase in disease and insect damage. For the householder, it means reduced supply, increased prices and reduced quality. The retailer also loses because the consumer stops buying fresh vegetables which are expensive and of poor quality. Flower plants are equally susceptible to hormone herbicides, so for the ornamental nurseryman or the gardener, it means a loss of production and quality, and an increase in disease and insect damage.

A confusing factor is that other agents such as incorrect fertilisation and viruses can cause some symptoms similar to those caused by hormone herbicides. To confirm field diagnoses, Dr Peter Hofman (Dept of Horticultural Science, University of Natal) has developed rapid and accurate ELISA and RIA tests (using rabbit antibodies to the herbicides) for the presence of hormone herbicides. Large-scale tests of plant, rain and soil samples taken from many different sites are being conducted, to confirm prior observations.

Airborne Pollution

Independent commercial laboratories in Durban and Cape Town are also testing plant, soil and rainwater samples in parallel. The results so far are disturbing in the extremely high levels of several hormone herbicides measured in many samples over the last year, levels which would certainly cause damage to susceptible plants.

The question then arises as to whether herbicide drift can be controlled. However, it is difficult to avoid entirely under ideal conditions, and impossible to avoid under farming conditions in South Africa. Drift from tractor spraying is

commonly between 10 and 20%, and from airplanes, 40-80%, of which at least 15% will permanently drift in the air (i.e., 1.5-3% and 6-12% of what is sprayed onto a crop of sugar cane will drift more than a kilometre from the original field).

Another factor increasing drift damage is that volatile herbicides evaporate from the leaves onto which they have been sprayed, to mix with the air and drift away from the original target crop as a vapour. A minor component is the relatively low level of technical expertise and understanding of drift phenomena by farmers, and especially, spray operators on farms, but this is secondary to the primary physical causes of drift.

South Africa's wind systems can carry any pollutant, including herbicide spray drift, for tens to hundreds of kilometres without significant dilution. A recent CSIR report on acid rain pollution in the Vaal Triangle commented that the meteorology of South Africa has the worst possible combination of geographical factors to produce serious airborne pollution problems.

Professor Preston-Whyte of the University of Natal has studied the wind systems of South Africa and Natal, in particular, for the last 25 years. (see previous case study.) He has pointed out that Natal has particularly severe air pollution problems in summer (the main hormone herbicides spraying season).

Any permanently airborne chemicals such as acid rain or chemical spray drift will stay in the air until rain or dew precipitates them onto the ground, or until ultra-violet rays break them down. Indeed, rain and especially dew concentrate airborne chemicals enormously (one mm of rain falling through a one km inversion layer will concentrate pollutants a millionfold).

Mist belts suffer most from airborne pollutants, concentrated and deposited in mist, the demise of the Black Forest in Germany being a typical example. The repeated observation of Natal vegetable farmers is that their worst damage occurs after light rain (concentration effect) following a dry period (build-up).

The widespread production of vegetables and their sensitivity to hormone herbicides has given us an effective

monitoring system of the extent and frequency of agrochemical drift. This can be extrapolated to all agrochemicals, the causes of drift being equal. Our findings with hormone herbicides, relative to our complete ignorance previously, indicate a need to monitor the content of air and rain for the presence of other pollutants on a routine basis.

Slow Resolution

Given the distances that pollutants can move undispersed in the air, it is clear that localised suspensions on the use of hormone herbicides will not be effective. The ineffective local ban around the Tala Valley is meteorological nonsense: winds do *not* follow international, provincial and especially local borders drawn on paper.

With the widespread use and incidence of hormone herbicide damage in all provinces, and the prevailing meteorological conditions conducive to serious drift incidence, the only meaningful control therefore would be a total suspension of hormone herbicides in South Africa. An alternative is the promulgation of a tight set of rules for hormone herbicide use, based on the Florida Rules, together with adequate policing of these rules.

Provincial suspension of herbicides would probably not work. A Natal suspension would be easily circumvented by purchasing the hormone herbicides in a neighbouring province. In the absence of any policing on the farms, this could not be detected or dealt with (Act 36 of 1947, the Act that controls the use of agrochemicals, does not control the *user* at all, a very serious deficiency).

In early 1989, the South African Minister of Agriculture's Advisory Committee on Hormone Herbicides, and senior South African government researchers at international conferences both concluded that it is probable that aerial pollution by hormone herbicides is a cause of serious problems for vegetable farmers in South Africa. Yet nothing has been done to resolve the issue, or is likely to be done, until further research has been completed which will clarify the finer details of the existing scenario. This may be achieved perhaps by late 1990 to mid-1991, some *five* years after this issue came into focus.

South Africa's wind systems can carry any pollutant for tens to hundreds of kilometres

The only meaningful control would be a total suspension of herbicides or the promulgation of strict national regulations

Extreme delays characterise the recognition of common health hazards, and effective action against pollution

Whilst one can recognise the complexity of the case, and the conflict of interests, the inability or unwillingness of relevant authorities to act in this case, 'without conclusive evidence' is a cause for concern. The goalposts of 'conclusive evidence' have been moved repeatedly.

In this case, because we are dealing with plant damage, we can repeatedly experiment until sufficient evidence does emerge. However, in any other case involving human health, the epidemiological data and resultant conclusions *will always* be tenuous and will probably be unrepeatable. Statistics can never prove a causal relationship, only indicate the likelihood of the existence of such a relationship.

It is possible, therefore, that any human health cases involving genuine problems would be overlooked or at best, difficult and slow to resolve because 'proof' is unobtainable, and that people could suffer disease and death in the interim. This observation is borne out by the extreme delays in the recognition of common health hazards such as cigarette smoking and asbestos, and of effective action to obviate their toxic hazards. The perspective that a registered agrochemical is 'innocent until proven guilty' requires careful examination and reconsideration.

The Tala Valley case showed that there appears to be no effective mechanism to resolve environmental conflicts

The dispute over the hormone herbicides is a complex story, a 'Jekyll-and-Hyde' situation of value and destruction; a decision to retain or to ban the hormone herbicides will hurt one or the other community. A disturbing issue which has emerged from the Tala Valley case is that there appears to be no effective mechanisms in our current society to tackle and resolve environmental issues without resorting to the frighteningly expensive, confrontational and essentially destructive process of lawsuits.

The use of the media and of petitions by the public to take shots at opposing sides are clearly acts of last resort. There is no medium through which the public can articulate their feelings and wishes on environmental issues at the level of decision-making. In the absence of such a medium, desperation easily turns to unreasonable hysteria, which generates polarisation and the development of fixed positions, after which reasonable compromise become impossible.

Solutions

Many similar issues will emerge with regard to the use, and occasional abuse, of agrochemicals in agriculture with the emerging environmental consciousness of the general public. However, alternatives or integrated practices reducing our dependence upon agrochemicals, such as the use of disease resistance and biological control, are mostly undeveloped, with limited resources being allocated to their development. It is therefore likely that, for the short-to-medium term, agrochemicals will remain essential to agriculture, and to our society's well-being. It is the balance between use and abuse that needs our careful monitoring.

It is also notable that these problems transcend politics and will be equally relevant in a post-apartheid South Africa. Indeed, they are universal issues being debated throughout the contemporary world with a determination to resolve them.

Constructive environmental action in South Africa today, which would not destructively deny agriculture essential tools with which to produce our food for the present, could include the following goals:

- the reallocation of research resources to the development of alternative agricultural systems minimising agrochemical use;
- examination of the need for an independent body answerable to the public for the registration and effective monitoring of current agrochemical usage, equivalent to the USA's Environmental Protection Agency. This, as opposed to the current situation in South Africa, where the Department of Agriculture conducts these functions, and serves the agricultural community, which may create a conflict of interest when there is conflict within the agricultural community.
- Monitoring should include the routine, country-wide testing of air, rain, surface water and groundwater and foodstuffs. Is the community-at-large prepared to pay for such an exercise?



- the development of a pro-active registration process for the use of pesticides on minor crops;
- the modification of Act 36 of 1947 (governing agrochemicals) to include control over the end-user of agrochemicals, over whom there is no control at present;
- the development and implementation of an effective education of farmers and their staff in the optimal use of agrochemicals, and the licensing of all agrochemical applicators;
- the solution of technical problems limiting the provision of safety for agrochemical applicators, and for the safe disposal of pesticide containers and unused sprays;
- the education of the public into a realistic perception of the actual risks

posed by current agrochemical usage, and their current role in agricultural productivity. This is not a black-and-white issue but a grey one, and excessive reaction to low risk situations may be counter-productive (e.g., the withdrawal of Alar® in the USA will probably increase cancer incidence due to aflatoxin production in the increased numbers of windfall apples);

- the development of structures allowing for the rapid, objective resolutions of environmental conflicts, before resorting to the courts of law; and
- the development of a forum for the articulation of the public's fears with respect to agrochemicals, at decision-making levels. The appointment of an ombudsman has been suggested by many scientists. **IPAA**

Constructive environmental action should not deny agriculture the essential tools with which to produce the nation's food

Environmental Strategies

CLEANING UP OUR ACT

Professor Rob Preston-Whyte
Department of Geographical and Environmental Sciences
University of Natal

Choices about the level of air quality concern how much it will cost to impose controls, and who should pay

Only governments can coordinate technological inventiveness, legal constraint and economic incentive for clean air

Emissions from industrial, commercial, transport and domestic sources become an air pollution problem when they exceed the natural cleansing ability of the atmosphere. Over the centuries there have been numerous attempts to resolve this problem, usually by applying legal restraints or economic controls. For example, the first known air pollution control law directed at the burning of 'sea' coal was passed in 1273 by King Edward I of England, while in 1300 King Richard III placed a heavy tax on 'sea' coal in order to discourage its use.

While air pollution control strategies have become more sophisticated in recent times, the underlying problems still remain. These concern the conflict between the recognised need to improve air quality, on the one hand, and the need to promote prosperity and employment opportunities, on the other hand. Choices have, therefore, to be made concerning the level of air quality, how much it will cost to obtain and who should pay. Only government can resolve these conflicts since they involve the need to coordinate the necessary blend of technological inventiveness, legal constraint and economic incentive for the provision of a desirable air quality.

Air pollution in South Africa is controlled by the Atmospheric Pollution Prevention Act 45 of 1965. In terms of this Act the control of industrial sources of pollution is regulated by certificate requirements which require the polluter to comply with minimum specification standards. Permission is granted by the state-appointed Chief Air Pollution Control Officer. This official is not bound by air quality standards. Instead the 'best practicable means' approach is adopted which attempts to attain a balance

between the availability of technology to achieve reductions of specific emissions and the financial impact on firms required to install the equipment. With the exception of smoke control from fuel-burning appliances and from motor vehicles, the Act does not specify emission standards for industrial pollutants.

Although the air pollution prevention programme initiated by the Air Pollution Prevention Act has resulted in measurable success in terms of smoke control in many South African cities, Rabie and Erasmus (1983:35) were still able to bemoan the fact that, 'When one looks at the polluted skies in many of our noisy cities and even towns it is often hard to believe that South Africa has laws to protect the environment. Since a reasonably satisfactory legal basis for positive action exists, the fault must be traced back to lack of adequate enforcement'.

In addition hazardous pollutants, such as sulphur dioxide, either have not declined significantly or have increased as is the case in the eastern Transvaal highveld.

With rapid urbanisation, and concomitant population growth, taking place on an immense scale in many urban areas in South Africa, it must be assumed that industrial development will accommodate the employment aspirations of this burgeoning population. It is, therefore, imperative that timely steps are taken to set in motion strategies that will reduce air pollution to acceptable levels. The Air Pollution Prevention Act is due for amendment. Now is the time for the development of imaginative air pollution control strategies.

Imaginative Controls

Strategies for reducing the impact of air pollution take different forms. Some of the more common can be listed as follows:

- *Air quality standards*

This involves the reduction of pollution at source by the specification of pollution-reducing equipment or type of construction or the setting of stack emission standards for specific pollutants.

- *Land use zoning*

This is also commonly employed in urban areas with industrial land use separated from residential areas. An interesting study of the relationship between land use and pollution in 76 metropolitan areas in the United States showed that city structure was also important. After taking into account city size, population density, transport systems, economic functions, etc., it was found that a core-orientated, radially-structured urban form was less polluted than a dispersed pattern characterised by low-density urban sprawl (Berry, 1974).

- *Dispersion*

By constructing high smoke stacks to ensure emission above the top of surface inversions, it is hoped that pollutants will be diluted to the point where they will cease to be a local problem. This strategy has been widely applied in the United States to avoid infringing the US Clean Air Act. In Michigan in particular it is common to see stacks with heights of 200m and some even exceed 300m. This practice has reduced surface pollution measurements in the United States but has contributed to the export of pollution, with a concomitant acid rain problem, to an increasingly resentful Canada.

- *Residual taxes*

Economists have long argued that the use of charges whereby the polluter must pay a tax or fee for each unit of pollution emitted would force firms to internalise external costs. However, while theoretically attractive, residual taxes have seldom been applied by governments.

- *Economic Incentives*

The basic premise underlying the economic incentive approach is that market forces can be used to reduce pollution to desired levels more

Data Base

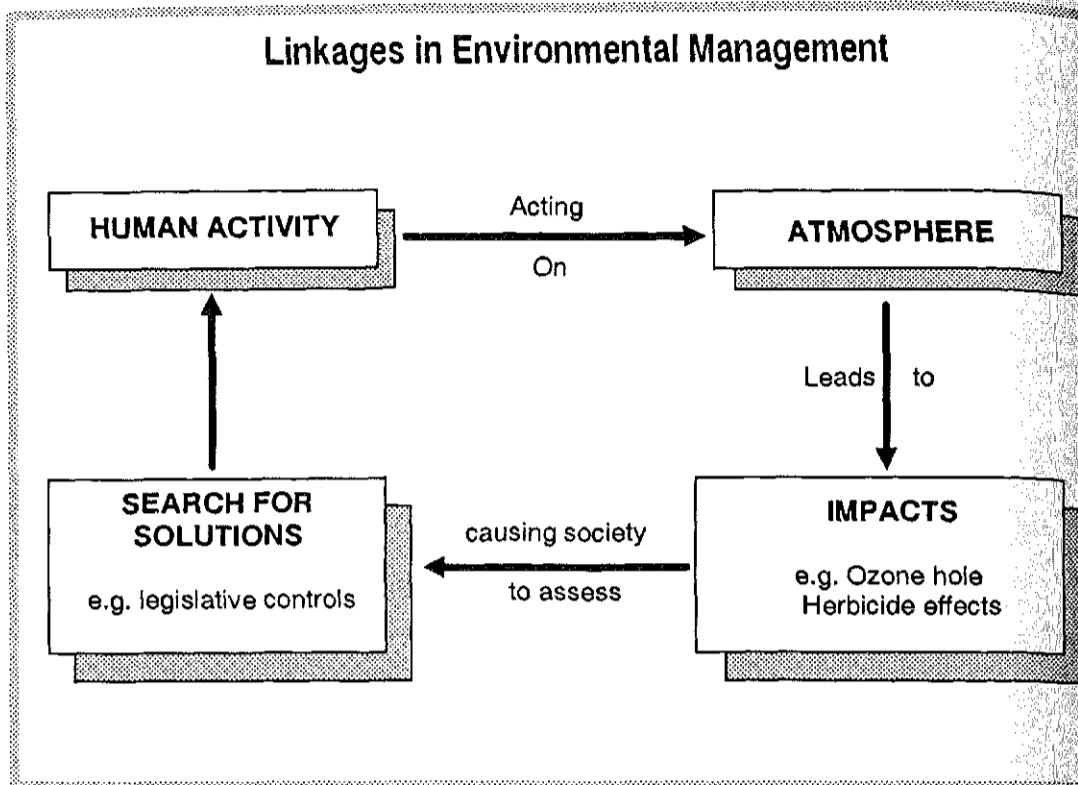
Command-and-Control Regulation The US Clean Air Act

The decade of the 1970s in the United States was a period in which concern for the environment led to the introduction of agencies to deal with environmental pollution. That the first law of the decade, signed by President Nixon on 1 January 1970, was the National Environmental Policy Act, was seen as a national commitment to improving environmental quality. This was followed by the creation of the Council on Environmental Policy to advise the President on such matters.

Fifteen units from existing government departments were consolidated into a single independent federal agency called the Environmental Protection Agency (EPA). This agency was charged with the responsibility for setting standards and regulations for air and water pollution, solid waste, noise, pesticides and environmental radiation. It also had to monitor pollution and interact with state and local government over environmental issues. One of the landmark laws which provided the EPA with authority and responsibility to monitor and manage the national air resource was the Clean Air Act Amendment of 1970.

The Clean Air Act Amendment of 1970 and subsequently 1977 has resulted in a considerable improvement in air quality. Since 1970 atmospheric pollution in the United States has been reduced to the point where national standards for sulphur dioxide, total suspended particulates, nitrogen dioxide and lead have been reached almost everywhere. It is, therefore, worth looking at the various tasks which the EPA was required to perform in terms of the Act. These were far reaching and required the EPA to:

- Establish national primary and secondary ambient air quality standards. Standards were subsequently set for total suspended particulates, sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead.
- Administer state implementation plans. States were required to submit plans to the EPA for the attainment of ambient air quality goals.
- Establish standards of performance for new stationary sources. These were to reflect the emission limitation achievable through the application of the best available technology, taking into account the cost of achieving such a reduction.
- Provide national emission standards for hazardous air pollutants. The EPA is required to list hazardous pollutants for which no ambient air quality standard is applicable.
- Administer implementation plans for non-attainment areas. Restrictions are placed on the growth of new pollution sources in areas which had not attained National Ambient Air Quality Standards for the pollutant concerned.
- Prescribe standards for motor vehicles, regulate fuel and fuel additives and regulate aircraft emissions.



US legislation presupposes that market forces can be used to reduce pollution more efficiently than by direct regulation

efficiently than by direct regulation. The United States government have experimented with economic incentives in air quality management as set out in their Clean Air Act. This is a relatively novel development which deserves further elaboration, particularly as US experience could well be valuable in amending the South African Air Pollution Prevention Act 45 of 1965.

Economic Incentives

The US Clean Air Act Amendment of 1970 established a command-and-control regulation system (see box) based on the setting of standards at a level which would provide an adequate margin of safety to protect public health. The Act was oblivious to costs however, with no attempt made to balance the benefits associated with cleaner air with the cost of reaching these levels. The 1970 Amendment decreed that no new sources were permitted in non-attainment areas.

By 1975, prompted by a changed US socio-political environment, a national economic recession, the Arab oil embargo and a growing awareness of the economic consequences of retarding growth, powerful stimuli existed favouring industrial development. The direct result of these pressures was that

the Environmental Protection Agency (EPA) began to experiment with various economic incentives based on the trading and banking of emissions, presumably on the premise that market forces could be used to reduce pollution to desired levels more effectively than direct regulations.

The first type of incentive took the form of an offset policy and was incorporated into the 1977 Amendment of the Clean Air Act. The objective of this policy was to allow areas that had not attained National Ambient Air Quality Standards to grow without further exceeding the standards. This was to be achieved by offsetting increased emissions from new or expanding sources against reduced emissions from existing sources. The importance of this innovation lies in the implication that emitters have property rights in their emissions that are transferable to other sources.

In its 1979 revised form of the emission offset policy, the EPA opened the way for the second form of incentive known as offset 'banking'. States were encouraged to develop a difference between the existing air pollution levels and national air quality standards by strict requirements on existing sources. This difference or growth margin could then be banked and sold or allocated to new or expanding sources.

Finally, the so-called 'bubble' policy addressed the control of stationary sources on a stack-by-stack or equipment-by-equipment basis. Up to this point a single plant, with several stacks and a diversity of equipment, was subject to a variety of control rules and emission limitations. In terms of the 'bubble' policy, the stacks in a plant are grouped together as if enclosed by a bubble.

Instead of the separate control of emissions from each stack in the plant, control is applied to the cumulative emissions from the bubble. Provided that the overall air quality is not lowered, the firm is permitted to vary emission controls from sources within the bubble, undercontrolling where control is costly and overcontrolling where control is cheap. The firm is, therefore, able to trade emissions from different stacks within the bubble.

The policy of grafting economic incentives onto a programme of direct control by regulation represents a move towards increased efficiency through the creation of a market in pollution rights. The bubble policy in particular is proving popular because it allows firms to reduce pollution in the most economical way. In one study it was found that the bubble approach saved the Du Pont Company, 60% as compared with the standard source-by-source regulations.

SA Parallels

The South African economy cannot afford activities that retard economic growth. However, society also cannot afford to ignore the costs imposed by atmospheric pollution. South Africa is facing many of the problems experienced by American in the mid-1970s. The success of air pollution reduction

strategies in the United States suggests that this country should contemplate similar strategies to cope with potential pollution problems in the next decade. These should be incorporated in the forthcoming amendment to South Africa's Air Pollution Prevention Act.

Amendments should include the development of a single department, similar to the US EPA, responsible for environmental matters. This department should be responsible for:

- the definition of air quality control regions and the establishment of a system of plant specifications and emission standards to achieve the desired air quality,
- investigating and implementing economic incentives that could be applicable in South Africa, taking cognisance of the American experience;
- imposing emission standards for new motor vehicles and the regulation of fuel additives with the objective of eventually eliminating the lead content; and
- investigating the establishment of emission standards for hazardous pollutants

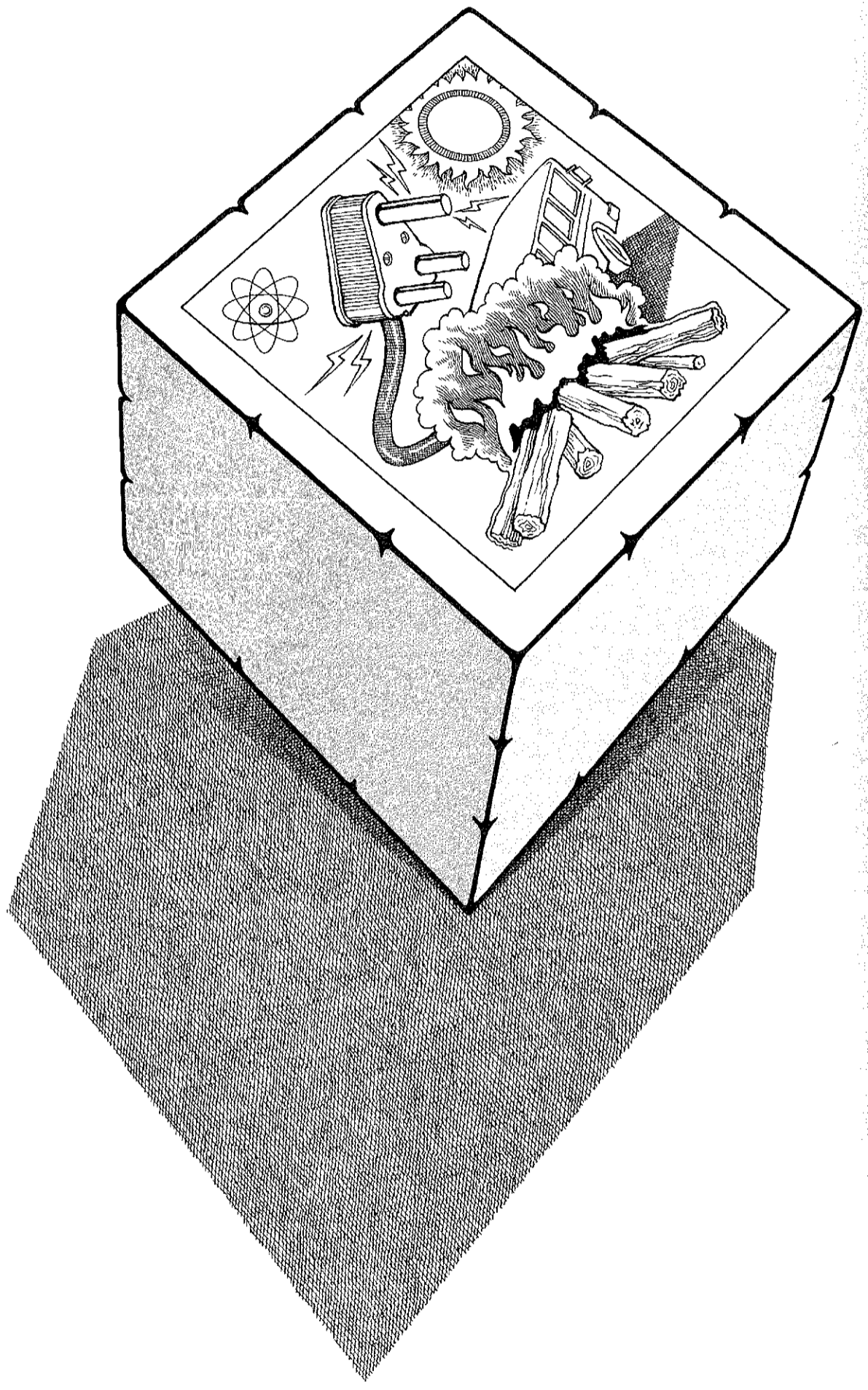
Pollution control is costly and inevitably will counter resistance from those asked to bear the cost of the control measures. However, damage costs are also prohibitively high and will become higher in the future. South African environmental managers would be wise to take the opportunity to initiate legislative changes now in anticipation of future problems. **IPQA**

REFERENCE

Rabie MA and MB Erasmus. 'Environmental law'. In RF Fuggle and MA Rabie (eds), *Environmental concerns in South Africa*. Cape Town: Juta & Co, 1983.

Increased emissions from new smoke-stack sources may be offset against reduced emissions from old sources

The South African economy cannot afford controls that retard growth, but also cannot afford the high costs of pollution



Part 3 Overview

PLAYING WITH FIRE

Ancient cave dwellers learned to rub two sticks together to create fire, which then provided them with all their energy requirements for warmth and cooking. Many people, even today, are still dependent on the fire from primary energy sources such as fuelwood and coal for their energy needs.

For most of the modern developed world, however, the form of energy has changed - from the flames of a fire to the power of electricity. We have learned to harness energy in electrical form from coal, oil, the sun and the atom and to put it to work to improve the quality of our life. Energy is the lifeblood of our society and economy. It keeps the wheels of industry turning and fuels our homes and cars.

As the demand for energy soars due to the ever expanding population and their improved quality of life, so the environmental impacts of energy usage multiply. The environmental problems associated with the combustion of fossil fuels, such as coal and oil, which provide us with electrical energy surpass those of most other industrial and agricultural activities.

In this section we look at the management of our energy resources and needs:

- The first case study discusses environmental impacts such as greenhouse warming and acid precipitation which result from the burning of coal.*
- The second case study reports on new research findings which further expose the damaging effects of acid rain on our ecology, with specific reference to the Eastern Transvaal highveld and the Drakensberg.*
- The third case study outlines the energy supply and demand patterns in South Africa. The authors emphasise the importance of coal in providing 90% of our indigenous energy supply, and highlight the inequalities in energy consumption patterns in South Africa.*
- The concluding article contrasts the commitment of South African energy policy to coal and the almost total disregard for our renewable energy resource base. An environmental strategy which could potentially alleviate some of the disastrous environmental effects is discussed.*

Case Study 1

ACID RAIN, GLOBAL GREENHOUSE

Professor Roseanne Diab
Department of Geographical and Environmental Sciences
University of Natal

Power generation is associated with many negative environmental impacts. The combustion of coal in particular, creates environmental problems that surpass those of most other industrial activities.

From the moment that coal is extracted from the ground until the time that it reaches our homes and industries as electricity, environmental problems abound. Problems such as the visual blight of mining, the pollution of our skies and surface and underground water systems, greenhouse warming and the smouldering of discard coal dumps are but some of the many impacts. Greenhouse warming and acid precipitation are two such issues which are currently in the spotlight.

Greenhouse Warming

1988 was the warmest year this century! Six of the warmest years on record were experienced in the decade of the eighties! (see figure 1). It is no wonder there are fears that we are entering a phase of unprecedented global warming, which will lead to melting of the polar icecaps, rises in sea level, flooding of coastal cities, desertification and dramatic changes in food production patterns. A factor undoubtedly linked to this warming trend is the greenhouse effect.

The analogy between the earth's atmosphere and a greenhouse is a simple model which explains how warming can occur. Temperature in a greenhouse is maintained above that of the surroundings chiefly because of the ability of the greenhouse glass to allow short wave radiation from the sun to pass unhindered. It is then absorbed by the surfaces within the greenhouse and subsequently re-emitted as long wave (heat radiation) rather than short wave radiation, because of the substantially lower surface temperatures here compared with the sun. Since glass is opaque to long wave radiation, the waves are unable to escape and consequently heat the interior of the greenhouse (see figure 2).

In the same way, the atmosphere, or rather the constituents of the atmosphere, are transparent to solar radiation, yet opaque to long wave radiation from the earth.

One of the main greenhouse gases responsible for the warming of the earth's surface is carbon dioxide (CO₂). Ever since the Industrial Revolution, CO₂ levels have been rising. They now stand at 348 parts per million (ppm), compared with 280 ppm at the beginning of the Industrial Revolution. In recent years an additional source of CO₂ has been deforestation. However, industrial

We are entering a phase of unprecedented global warming - 1988 was the warmest year this century

Industrial emissions of CO₂ still outweigh deforestation as a contribution to the Greenhouse Effect

There is an urgent need to curtail industry's emission of CO₂ and other greenhouse gases such as methane, nitrous oxides and CFC's

emissions still outweigh the contribution of deforestation by a factor of about three.

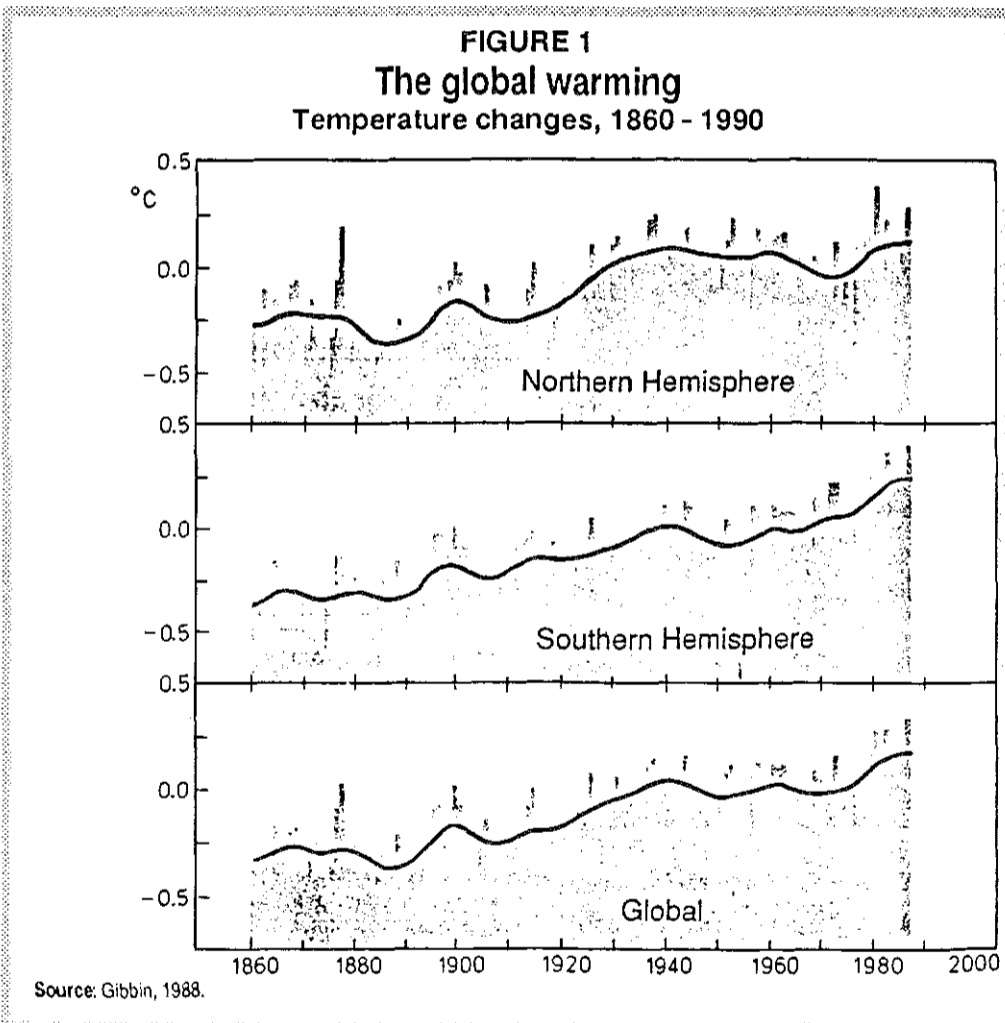
Vast amounts of CO₂ are emitted from coal-fired power stations in the eastern Transvaal highveld, the power house of South Africa. Emissions are estimated at 124m tons per annum, of which more than 95% originates from power stations (Els, 1987). This is equivalent to a continuous line of ten-ton trucks encircling the globe at the equator almost four times ($\pm 150\,000$ km).

Scientists predict that if CO₂ levels reach 600 ppm, which is not impossible by the year 2050, that global temperatures could increase by an average of 3°C above present values, with the greatest impact

Despite the possibility that such natural feedbacks could counteract the full impacts of greenhouse warming, there is a very urgent need to curtail our emissions of CO₂ and other greenhouse gases such as methane, nitrous oxides and CFC's, into the atmosphere. Only then will the fears of flooding and food shortages subside.

Acid Precipitation

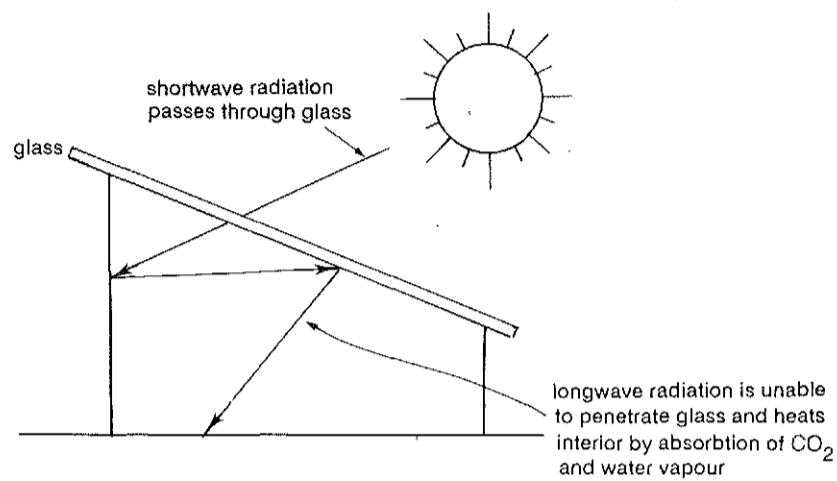
Acid precipitation or acid rain as it is more commonly known, is another environmental issue in the spotlight (see following case study). It is something we associate with the destruction of the Black Forest in West Germany, or with



being felt at the poles. The difficulty in forecasting an exact temperature rise is due to the numerous secondary effects which may counteract the warming effect of CO₂. For example, warming would be accompanied by increased cloud cover which has a cooling effect.

the killing of fish in the lakes in Scandinavia. Yet acidity levels in rainfall in some areas of South Africa are equivalent to those which are causing such damage to the ecology in Europe and North America. Acid rain is also fast becoming an issue in South Africa.

Figure 2
The Greenhouse Effect



Sulphur dioxide emissions in the highveld are five to ten times higher than the worst conditions found in western nations

Acid rain derives from a reaction which takes place between sulphur dioxide (SO₂), emitted largely from coal-fired power stations and the water vapour present in the atmosphere. Sulphuric acid is formed, which is then washed out with precipitation at considerable distances downwind of the source. Acidity is measured on a pH scale, where 7 represents neutral, pure rain water has a pH of 6 and vinegar 3. The lower the pH, the greater the acidity.

Typical pH values in the vicinity of the eastern Transvaal highveld are in the range 3,9 to 4,6 (Tyson et al, 1988) This is not surprising since the SO₂ emission density in the highveld is between five and ten times greater than the worst conditions found in most western industrialised nations. Added to this are extremely unfavourable atmospheric conditions, particularly during winter months, for dispersing pollutants.

Impacts of acid precipitation originating in the highveld are likely to be felt by all components of ecosystems, from soils to water systems to plants. Particularly vulnerable are the pine and black wattle forest plantations of the Eastern Transvaal and Natal. Forests, due to their

longevity, experience cumulative effects of acid precipitation. All the well-known symptoms of flecking and mottling of pine needles, decline in productivity, needle shedding, and crown decline or 'stork's nest' appearance, have been reported in the Eastern Transvaal, but there has been no conclusive link to pollution damage.

Most of the soils directly affected by highveld pollution have a very poor buffering capacity against acid precipitation, because they themselves are acidic. Lakes and rivers, on the other hand, are mainly alkaline and therefore relatively insensitive.

Soils and forests are clearly potentially at risk and although conclusive evidence of pollution damage is lacking, there is sufficient cause for concern. A close watch must be kept on acidity levels in rainfall and forest damage on the eastern seaboard of South Africa. **UWA**

REFERENCES

Tyson PD, FJ Kruger and CW Louw. Atmospheric pollution and its implications in the Eastern Transvaal Highveld. SANSP Report No 150. Pretoria: CSIR, 1988
Gribbin J. Britain shivers in the global greenhouse. *New Scientist*, 9 June 1988:42.

The impact of acid rain is likely to be felt by all components of ecosystems, from soils to water to plants

Case Study 2

SING(E)ING IN THE RAIN

Graham Howe, Editor,
Indicator Project South Africa

Acid rain poses urgent questions about the environmental costs of our traditional energy sources

Thousands of acidified Scandinavian lakes and dying European forests show the scars of acid rain

Clean rain is no longer a gift of nature we can take for granted. A new form of manmade air pollution has caused great concern among scientists and ecologists over the last two decades.

Chemicals released into the atmosphere from major industrial areas in northeastern America and western Europe have gradually upset the natural balance of 'clean' rain and snow. Nature's own cleansing agents now contain large quantities of dilute sulphuric and nitric acids. These pollutants are deposited by acid rain on the earth's surface and reabsorbed with devastating ecological consequence.

A whole range of aquatic life from otter to trout are unable to survive or reproduce in the altered environment of thousands of acidified Scandinavian lakes and polluted North American waterways. Yet the desperate attempts of ecologists for the enactment of the pollution controls needed to fight acid rain have been complicated by the fact that fall-out often occurs more than a thousand kilometres from its industrial source.

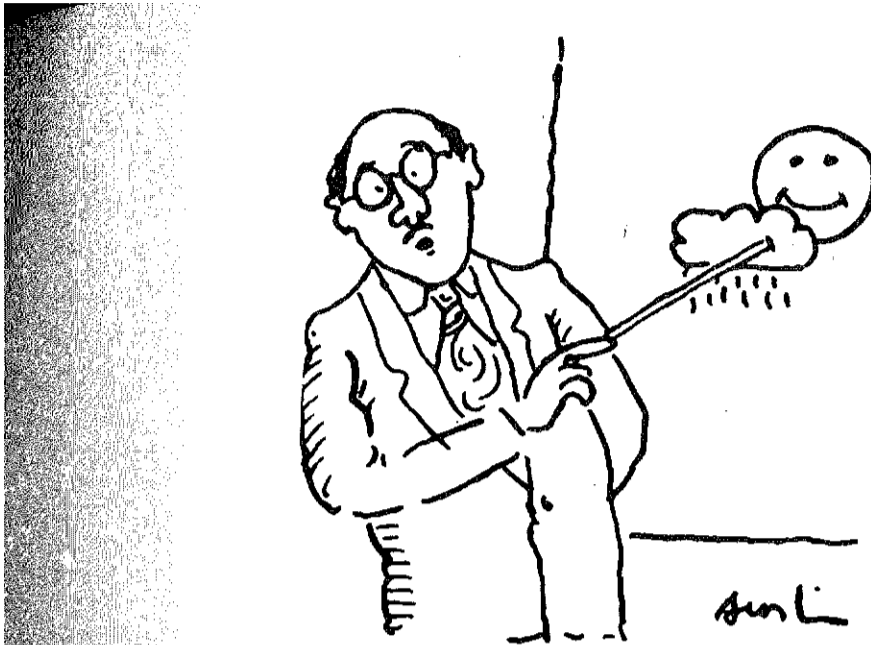
Acid rain poses urgent questions about our traditional energy sources and the environmental costs of industrial growth. International scientific and political co-operation are required for effective resolution of this ecological equation. A closer look at this manmade dilemma of science brings into focus the basic human issues of our long-term survival and co-existence in the only habitable universe we know, with its finite store of natural resources.

Industrial Ingredients

The use of fossil fuel such as oil and coal to fire power plants causes large quantities of the gas sulphur-dioxide to be released into the atmosphere during combustion. Utility plants that generate our electricity supply are responsible for two-thirds of these chemical releases, though industrial smelters and boilers also contribute their share of what scientists term 'anthropogenic emissions' (pollutants of manmade origin). The most dramatic instance of this kind of air pollution was a Canadian copper-nickel smelter which released enough sulphur dioxide during the 1960s to equal the estimated amount emitted from a natural source: all the world's volcanoes!

In South Africa, much of our air pollution originates from the same industrial sources of acid rain, namely the Iscor complexes, oil refineries, ore-smelters, and principally, the Escom power stations in the central Transvaal. It is estimated that these sources collectively emit one million tons (Mt) of sulphur dioxide (31 tons per km²) per annum into the atmosphere. (Comparatively, an international pollution index shows annual sulphur levels of 30 Mt in the USA and 50 Mt in Europe.) Emissions from the eight power stations in the eastern Transvaal ranks the highveld alongside Eastern Germany as two of the world's worst affected acid rain regions.

Domestic consumption of coal in South Africa's urban areas also contributes to high air pollution levels. Combustion from coal stoves in non-electrified township areas pours 50 000 tons of



"... and scattered acid rain showers."

Source: *Insig*, September 1989.

sulphur dioxide per annum into the atmosphere at ground level. Our vast domestic supply of coal is characterised by a low sulphur content, however, compared to the coal used by other industrial nations. This crucial factor lessens the amount of air pollution in South Africa from one of the major sources of acid rain.

Another gas pollutant, nitrogen oxide, constitutes a growing junior partner in the chemical equation of acid rain. Its primary sources are car exhausts, power plants and fertilizer factories. This pollutant is increasing at a faster rate than sulphur dioxide because of the partial shift from coal to natural gas (low in sulphur content), as well as the worldwide numerical increase in the combustion of motorcar fuels (high in nitrogen content).

Earlier methods of pollution control were to install 'super' smokestacks up to 400m tall at industrial sites in smog-bound urban areas. This temporary solution reduced short-range pollutant fallout and improved the quality of air in the cities, but at an ironic cost. These tall stacks release fly ash and sooty plumes of smoke carrying the precursors of acid rain - sulphur dioxide and nitrogen oxides - which at this elevated height are easily transported by great air masses across regional and international boundaries for hundreds and even thousands of kilometres, where acid rain falls on an unsuspecting 'host' destination.

Airborne transportation of pollutants over long distances has led to official Canadian accusations that industrial sources in the highly industrialised north-eastern USA cause 50% of Canada's acid rain. More than 140 acidified lakes in Canada have lost their fishlife. In Europe, Swedish scientists trace 77% of artificial sulphur content in their air to foreign origins: predominantly the dense industrial sites of the German Ruhr Valley and northern England.

Closer to home, short-range rather than long distance pollution fall-out is causing problems in Cape Town. The topography of the city shapes a bowl-like setting which produces a notorious 'inversion' effect - heavy smog is trapped over the area and dissolves the sulphur and nitrogen pollutants to form acid rain. Under different wind conditions, however, chemical emissions from local power plants and factory smoke stacks can drift as far as the Hex River Valley before acid rain falls.

In Natal, new research findings have illustrated the devastating impact of acid rain on the forests and streams of the Drakensberg. A CSIR survey of streams at the top of the escarpment - where water quality is not contaminated by human sewage or agricultural usage - discovered high acidity levels, and as a direct consequence, impoverished aquatic life. The most damaged streams are in the central Drakensberg range around Golden Gate, the Natal/OFS boundary and the Transvaal/Swaziland border.

Average annual precipitation is now five to thirty times more acidic than clean, unpolluted rain

In spring in Europe, melting snow releases surface deposits of concentrated acid into aquatic ecosystems

Case Study

Hard Rain Over Cape Town

The effect of acid fall-out in Cape Town is a visible symptom of greatly increased air pollution throughout the world.

The interaction of pollutants in an unfavourable setting for wind dispersion can make pollution levels on some days in Cape Town even worse than some of the world's most polluted cities. The fresh coastal air prized by Capetonians contains more nitric oxides than Tokyo or Sydney and more sulphur oxides than London.

Acid rain made the news headlines in Cape Town as early as April 1973. Female office workers in the vicinity of downtown Table Bay power station complained of pollution-laddered stockings and pantihose. It was reported that one woman claimed she lost one new pair of pantihose in this way each day! Another worker received mild acid burns to her face, neck and arms from pollution fall-out while she walked through the city.

A daily plume of dense white smoke would pour forth from the stacks of the oil-fired electricity plant in Dock road and then descend on the lower slopes of Table Mountain, near the prestigious Disa Park flats complex. In near fumigation conditions, burglar-bar and steel railings corroded, plants wilted and residents suffered from obvious eye, nose and throat irritation. At the new BP centre, close to the source of this pollution, the air conditioning system was severely corroded after only two years in use.

Operations at the Table Bay power station were phased out over 1973 - 74 as a result of the international escalation of oil prices and local environmentalist pressure. Its daily release of large quantities of sulphur from oil combustion - a major precursor of acid rain - caused the dangerous 40 % level of sulphuric acid found in the city's atmosphere.

Samples of nylon pantihose were tested in the immediate fall-out area in April 1973 in an experiment supervised by a Woolworths quality control expert. Within hours, sheer pantihose exposed in this polluted environment developed holes at the point of impact of small black particles. Samples of heavier number 5 and 6 hoses were less obviously damaged, though laboratory testing showed a marked decrease in 'burst' strength, the common measure of stocking strength. The conclusion drawn was that these material effects were the result of typical acid damage.

In the western Cape today, two decades after the closure of this site, other power stations as well as various industrial plants continue to pump out the major ingredients of acid rain as chemical by-products of industrial combustion, sulphuric and nitrogen oxides.

Pollution Chemistry

Pollutant molecules of sulphur and nitrogen undergo various chemical transformations while being carried by winds through the atmosphere. As gases and dry particles, these pollutants interact with cloud water droplets to form weak sulphuric and nitric acids, which then fall to earth in a process described by scientists as 'wet deposition'. There are such increased quantities of these industrial by-products in the air today that average annual 'precipitation' (a catch-all meteorologists term for rain, snow, hail etc) over widespread regions is now five to thirty times more acidic than 'clean' rain produced in an unpolluted, ideal environment.

This radical change in the chemistry of natural precipitation has on occasions led to astonishing results. In a storm recorded in Scotland in 1974, the rain was found to have the acidic consistency of vinegar. Acid rain has an even more extreme effect in some countries in the northern hemisphere in Spring, when melting snow releases surface deposits of concentrated acid into aquatic ecosystems.

Although the acidification of lakes, rivers and forests by contaminated rains is well documented, research findings into the relationship between acid rain and crop yields, building corrosion and respiratory disease are incomplete. In South Africa, little research has been undertaken into the spreading problem and national statistics on average annual increases of acid levels in polluted soil and water are not available.

Acid rain has no state or national boundaries. In the words of research pioneers, Likens and Bormann, 'trends in fuel consumption, fuel preference and pollution control technology ... have transformed local soot problems into regional acid rain problems'.

The modern originator of acid rain research, Dr Svante Oden, a Swedish soil scientist, characterises this kind of long-range industrial pollution as 'chemical war'. His exaggerated tone is understandable as southern Scandinavia - along with most other north western Europe - is a zone of high acidity today. In Sweden alone, scientists estimate

20 000 acidified lakes to be devoid of aquatic life out of a total of 100 000 lakes in the country! Polluted rain has also been blamed for killing 25% of West Germany's renowned forests and 40% of Czechoslovakia's trees.

In northeastern America, rivers in acid rain hot spots such as the Adirondack mountains (New York State), Nova Scotia and Quebec (Canada) have had their salmon, bass and trout populations devastated. Acid rains causes \$5bn in environmental damage annually in this region. Sulphate pollutants also tend to scatter light and hazy visibility occurs. Acid precipitation has reduced average summer visibility in major eastern regions of the USA by as much as half over the last thirty years.

The poor visibility and smog in South Africa's townships is a widespread phenomenon. The sulphur dioxide concentration found in the air in Soweto exceeds 20 parts per billion on 93% of winter days; in the Eastern Transvaal, it exceeds this level on 16% of winter days! This means that visibility in the highveld is less than 7 km for 1% of winter time, but in Soweto is less than 7 km for 40% of winter time.

Control Costs

The belated legislation of strict pollution controls for industry can partly be explained by the paucity of research and the limits to scientific knowledge about acid rain until publication of Orden's findings in 1967. Subsequent breakthroughs by scientists were made in the 1970s. Acting on the new evidence conclusively linking industrial emission sources to distant acid rain fall-out, many European governments have pledged to achieve a 30% reduction in sulphur dioxide pollution by 1993.

In the USA today, there are 179 smokestacks of 150 metres high or taller, including 20 superstacks that tower at 305 metres! To meet standards set by the Environmental Protection Agency (EPA), newly built coal-based power plants must remove 70 to 90% of the gaseous sulphur before expulsion. However, the installation of expensive 'scrubbing' systems to achieve this is not compulsory for older plants which cost between \$69 and \$111 million to refurbish.

In South Africa, the capital outlay for installing a flue gas desulphurisation plant to support a single 3 600 MW power station would exceed R500m. The conversion to a cleaner production process would involve an additional R100m in annual running costs, and much of the basic 'scrubbing' equipment would have to be imported. The total cost of implementing sulphur pollution control at source would amount to an additional R140 per KW unit of power.

There is no similar national watchdog body such as the US EPA to regulate air pollution in South Africa. Under the Atmospheric Pollution Prevention Act of 1965, the Department of Health appoints a chief air pollution officer to monitor levels and set guidelines, but local authorities seldom go beyond setting 'recommendations' for industry. The Minister of Environment is guided by the Council for the Environment, which has a special Committee for Wastes and Pollution, but both bodies play a purely advisory role rather than one of law enforcement.

Clean air legislation in South Africa is based on the twin principles of voluntary observation by industry and the 'best practicable means' to control pollution levels. Furthermore, the Department is reluctant to fine companies which exceed set levels. Local scientists believe these safeguards to be wholly inadequate, especially the voluntary monitoring by industry of sulphur emissions from power plants. Companies conduct their own tests on pollutant outputs and no independent check is made on adherence to safety levels.

Political Economy

Beyond maximum use of 'scrubbed' low-sulphur coal, general fuel conservation, and the promotion of alternative energy sources, there are no easy solutions to the blight of acid rain.

For industry, pollution reduction methods are subject to straightforward economic factors such as the high cost of plant modification and reduced efficiency or productivity. For consumers, the cost of implementing pollution controls is partially financed from their pockets in the form of higher electricity bills and fuel prices. And for the state, the

The capital outlay for installing anti-pollution equipment at a single power station would be R500m

Weighed against environmental considerations is the need to electrify townships and improve quality of life

In the ongoing search for cleaner energy sources, one logical alternative to oil and coal is nuclear power

We may have to choose between the high risk of nuclear radiation or the slow cancer of fossil fuel pollution

enactment of environmental controls means that poorly financed local authorities must absorb some of the costs of anti-pollution law enforcement and increased electricity tariffs.

In short, policy-makers face a 'catch-22' dilemma in deciding whether to treat pollution before emission, on environmental impact or at both ends. In either case, the implementation of pollution controls imposes high costs. From the perspective of the electricity industry, cleaning up its act imposes production costs at source. From the perspective of the wood and paper industry, the dieback of acidified forests means lower yields and higher product costs.

The energy needs of poorly serviced working-class communities in a developing society must also be considered. In South Africa, the electrification of townships can mean a significant cost and time saving for black people who may otherwise have to search for fuelwood in denuded areas or pay inflated prices for fossil fuels. From this perspective, the external environmental costs of the increased national supply of electric power are obscured and outweighed by the visible improvement in the quality of life of these communities.


Weighed against these practical economic considerations (which tend to count heavily during a recession) and social benefits are the long-term costs of acid pollution and irreversible environmental damage. In 1989, North American and European industry pumped 80 million tons of sulphur dioxide into the atmosphere. Much of it is converted to acid rain which returns to earth with its lethal bounty, destroying remote, unspoilt wilderness areas and seeping into our water supply. Once, nature had its own ways of coping with the same pollutants. Volcanic eruptions and forest fires released sulphuric ash in quantities the earth

might safely absorb through natural processes. Geological buffers such as limestone and sandstone filter and neutralise acid released in pre-industrial quantities.

In the modern industrial age, some scientists believe that treating polluted, acidified lakes and rivers with lime is the most sensible solution as it responds to the problem where it surfaces. Others scorn this as a localised stopgap measure which treats the symptom, but not the source of pollution. They cite annual Swedish expenditure of \$40m on a lime treatment programme, and call for more effective trans-national support and coordinated responses. The lime solution means that over a thousand severely affected lakes will gain no more than a five year reprieve before renewed acidity sets in.

In the ongoing search for 'cleaner' energy sources, one logical alternative to coal and oil is nuclear-based power. This, in turn, raises other issues such as radioactive waste disposal and the Chernobyl disaster, which demonstrated the awful environmental consequence of human error in the management of nuclear plants. For the ordinary citizen, both this new, revolutionary energy source and traditional fossil fuels carry potential environmental hazards.

Ultimately, are we only left with a pessimistic choice between two equally undesirable alternatives - whether to exit with a bang (the high risk of nuclear melt-down and radiation fall-out) or a whimper (the slow cancer of daily air pollution from fossil fuels)?

Perhaps not. The new environmental consciousness of the 1990s and mankind's need for alternative energy sources may spur science and industry on towards a search for more creative solutions, before our environment suffers irreparable damage at our own hands. 

Case Study 3

FUELLING THE CRISIS

Peter Oxenham and Anton Eberhard
Energy Research Institute
University of Cape Town

The inequalities inherent in many developing countries are exemplified by their energy consumption patterns. South Africa provides a rather stark example. Containing 4% of Africa's population, South Africa generates 60% of the continent's electricity and yet less than a third of South Africans have access to electricity in their homes. Unequal access to basic needs including energy continues to keep the majority of the population in a state of underdevelopment.

In order to be clearly understood, energy supply and demand patterns must be integrated with the historical processes that have shaped the existing socio-economic and political complex. The close relationship between the distribution of energy and the distribution of political and economic power within the society is obvious. Primarily, the South African energy crisis is not concerned with the availability of energy but with its distribution.

Coal is the cornerstone of South Africa's energy economy, contributing approximately 90% of the total indigenous primary energy supply. The remainder comprise renewable and nuclear sources, contributing approximately 8% and 2% respectively. Biomass, mostly fuelwood, forms the greater part of the renewable component, followed by hydro-energy. Solar and wind energy currently contribute insignificant amounts.

South Africa imports approximately half of its oil requirements. The balance is produced from coal, with approximately

26% of the annual coal production converted to synthetic liquid fuels. However, most coal is used to produce electricity (53%), while some is used for direct heating applications.

Given the low conversion efficiency of coal to secondary energy forms, such as electricity and liquid fuels, and since biomass is most often used directly, the latter's contribution to nett energy is higher. Biomass thus contributes 14% and fuelwood 11% of the nett energy consumed in South Africa. Renewable energy already makes a significant contribution to the energy supply and cannot be ignored in energy policy formulation.

More than half of South Africa's population lives in underdeveloped rural areas where wood is the principal fuel for cooking and heating. A further fifth of the population living in unelectrified urban and peri-urban areas also relies on fuelwood for their energy needs. In many areas wood is becoming scarce, where wood gatherers have to walk further to collect daily supplies. In KwaZulu, for example, Gandar (1984) has found that the average distance walked in collecting one headload was over 8 kms, a journey which takes nearly 5 hours. Gandar states that, 'If wood gathering is counted as part of food preparation, more effort is put into the preparation of food than in growing it'.

Although fuelwood has been classified as a renewable resource, in many respects it is no longer so, as demand is exceeding supply. In a recent study Aron et al (1989) have predicted a 54% increase in

South Africa generates sixty percent of Africa's electricity, yet less than a third of South Africans have electricity

There is a close relationship in any society between the distribution of energy, and of political and economic power

If environmental degradation is to be halted, then fuelwood must be substituted with other fuels and electricity

Peri-urban households in South Africa have little access to fuelwood or electrification for their energy needs

homeland fuelwood consumption between 1980 and 2000. Using a model for supply and denudation of fuelwood the same study predicts a fuelwood deficiency of 4m tonnes in the year 2000.

Although this model incorporates a number of simplifying assumptions concerning expected population growth, urbanisation patterns and constraints of supply, it demonstrates that current levels of fuelwood consumption cannot be sustained. In fact, it is clear that a deficiency of fuelwood already exists, with some regions experiencing severe woodland denudation. For example, Aron et al (1989) have estimated that in KwaZulu the current supply of fuelwood from natural woodland is 1 300 000 tonnes per annum with demand (1980) estimated at 1 650 000 tonnes per annum.

If environmental degradation is to be halted an alternative energy supply must be made available to affected areas. Demand for fuelwood must be reduced through more efficient usage and substitution with other fuels and electricity. Short-term strategies must focus around current demand by increasing fuelwood supplies through afforestation programmes.

To meet the predicted year deficit by the year 2000, a plantation area of at least 200 000 ha is required in KwaZulu. The potential for woodlot development is, however, limited by the lack of suitable land within 'homelands'. To exacerbate matters, most of the land identified as suitable for afforestation has been earmarked for commercial forestry.

Peri-Urban Needs

While much of the attention on energy scarcities has focused on rural areas, the problem has begun to shift to peri-urban areas as South Africa experiences increasing rates of urbanisation. The peri-urban sectors are wedged between the metropolitan centres and rural areas. There is little access to 'free' fuelwood and most households are not electrified.

Peri-urban households rely on a variety of different fuels for their energy requirements including paraffin, candles, gas, wood, batteries and in a few cases, electricity. Rivett-Carnac (1979) has cited that in Umlazi outside of Durban,

un electrified households spend more than twice as much on fuels than better-off households with electricity.

There are a number of reasons why electrification is the preferred energy supply option for domestic needs:

- Electricity is the most versatile and convenient energy source that allows for the performance of entirely new tasks;
- Once the initial extension fee has been paid, electricity is in most cases cheaper than other fuels;
- Electrification can be a substitute for coal and wood usage in urban areas, and this may substantially reduce the air pollution in metropolitan areas; and
- It will ameliorate the fire hazard of fuels such as candles and paraffin which cause the deaths of hundreds of people every year.

South Africa has more than enough capacity to supply electricity to all inhabitants. The capital cost of connecting all households to the electrical grid has been calculated by Dingley (1988) as R8bn. If spread over ten years this would amount to 20% of Eskom's current capital expenditure.

Solutions

At present, 80% of South Africa's commercial energy is supplied by coal-fired power stations. This reliance on coal will continue in the short and medium term. Of a total installed capacity of 34 000 MW, approximately 25 000 MW is generated within a 200 km by 200 km area of the eastern Transvaal highveld, where most of the major coal fields are located. As a result, excessive sulphur dioxide emissions and resultant 'acid rain' are becoming major environmental hazards (see preceding case study). The scarcity of water in this region has become another major problem which limits the construction of new coal power stations.

The government and its nuclear agencies have committed South Africa to the increased use of nuclear energy. Funding of research and the development of a



nuclear energy industry has so far amounted to billions of rand. Renewables currently receive only 0,1% of the amount spent on research and development of nuclear energy.

However, current nuclear technology does not provide a long-term solution either. Apart from the serious environmental concerns surrounding radioactive waste disposal, current stocks of uranium are unlikely to last more than half a century should South Africa embark on a large nuclear station building programme. The future of nuclear energy depends entirely upon the commercial viability of the fast breeder reactor which is still far from proven, with the major industrialised countries having terminated their experimental projects in this technology.

Central and Southern Africa contain vast hydro-electric resources. Olivier (1988) reports that a conservative estimate of the hydro-electric potential of the White Nile, Zambezi, Zaire, Rufiji, Shire and Cunene rivers amounts to 70 000 Mw. However, international cooperation is essential if this massive renewable energy resource is to be fully utilised.

There is no reason to be certain that nuclear will provide the only option and that all our research and development should be allocated to this field. Any rational decision making regarding future energy supply options must of necessity include renewables, fusion, and hydrogen energy. Alternatives to nuclear must be given the chance to provide our energy needs of the future. IDQA

REFERENCES

- Aron J, A Eberhard and M Gandar Demand and supply of Firewood in the Homelands of South Africa. Second Carnegie Inquiry into Poverty in Southern Africa, Post Conference Series No 19. University of Cape Town: SALDRU, 1989
- Dingley CE. Macro cost estimate for a National Electrification Programme. Interim Report 15. University of Cape Town: Dept. of Electrical Engineering, 1988.
- Gandar MV. The poor man's energy crisis: Domestic energy in KwaZulu. Carnegie Conference Paper No156, op.cit.: 1984.
- Olivier H in AA Eberhard and AT Williams (eds) *Renewable Energy Resources and Technology Development in Southern Africa*. Cape Town: Elan Press, 1988.
- Rivett-Carnac JL. A strategy for electrification of black townships in and around Durban and its impact on the energy situation in South Africa.

Nuclear technology does not provide a long-term solution and raises other environmental problems

Environmental Strategies

POWER STRUGGLES OVER ENERGY RESOURCES

Professor Roseanne Diab

Department of Geographical and Environmental Sciences
University of Natal

Two decades after the worldwide oil crisis, renewable energy sources are poised to play a vital role

Interest in renewable energy was awakened in the early 1970s, around the time of the worldwide oil crisis. Renewables were touted as the solution to our rapidly dwindling oil and coal reserves. Not long afterwards, the hysteria surrounding the oil crisis subsided, as did the initial euphoria of solar water heaters, battery driven cars and the like. Surprisingly, however, renewables survived, and in so doing, entered a new era, having acquired a greater maturity and vision. Now, almost two decades later they are poised to play a vital role in global energy supply.

Whilst highly regarded in many countries as having a significant, albeit small, contribution to make towards securing an energy supply, such recognition is not accorded renewable energy in South Africa. The pie graph depicted in figure one is very revealing. It underlines our heavy dependence on coal and it also reveals our almost total disregard for the renewable energy resource base of our country.

An unfavourable government energy policy explicitly states that coal will form the cornerstone of South Africa's energy economy well into the next century, and that nuclear energy will succeed coal. Renewable energy is dismissed with a wave of a pen, reducing its relevance to no more than a few paragraphs in official statements.

The luxury of such a policy is all the more short-sighted when considered in the light of worldwide trends to enhance, rather than diminish, the role of renewable energies. For example, in 1973, Denmark was 99% dependent on imported energy supplies, of which 93% was oil. In the space of twelve years this dependence on oil was reduced from 93% to 53%. Part of the reduction in oil dependence has been achieved by energy savings but a large portion is explained by increased reliance on renewable energy, specifically wind energy. The ultimate objective of the Danish government is to raise the contribution of wind to electricity consumption to 10%. Denmark is typical of most European nations, all of whom are actively encouraging the increased role of renewables.

A further major inhibiting factor in the expansion of renewable energy usage in South Africa is the pervasive myth that electricity generation from coal is the cheapest. It is certainly very inexpensive when compared with other parts of the world and other forms of energy. However, we should not lose sight of the fact that the price of coal does not include externalities such as impacts due to pollution, cleaning and health costs and so on. Only if all these external costs are included into the pricing of coal do we have a realistic base for comparing fossil fuels and renewables.

South Africa's energy policy is committed to coal and nuclear energy, and dismisses renewable energy resources

The pricing structure of electricity in South Africa is such that there is no differentiation between different parts of the country. Effectively, consumers in the Transvaal are subsidising consumers at the coast who are situated a long way from the power stations. With a different pricing structure, renewables would be more competitive in some geographical locations.

This is not to imply that the only application for renewable energy is electricity generation connected into the national grid. Renewables are eminently suited to dispersed deployment in the rural areas of South Africa where loads are small and distances between points large, since renewable energy is generally diffused over a very large area. It therefore has a very valuable role to play in meeting the nascent energy demands of the rural and underdeveloped sectors of South Africa.

Alternative Forms

There are many renewable energies which are worthy of exploitation in South Africa, such as solar, wind, hydro, wave and biomass, and others such as geothermal and tidal energy, which are not.

The solar energy resource in South Africa is amongst the most favourable in the world and is vastly under-utilised. Applications range from the production of thermal energy to provide heating and cooling facilities, to the conversion of solar radiation into electrical energy by means of photovoltaic cells.

Penetration of solar water heaters into the domestic market thus far has been very limited and there are many reasons for this, not least of which is the lack of government support. Photovoltaics offer great potential for development in the South African market. They have rapidly taken off in the telecommunication sphere and are increasingly finding acceptance in remote farms and institutional structures, such as schools, clinics and administrative offices in underdeveloped areas.

Hydro power is generally accepted to be one of the cheapest methods of generating electricity. A tendency common in many countries is to install

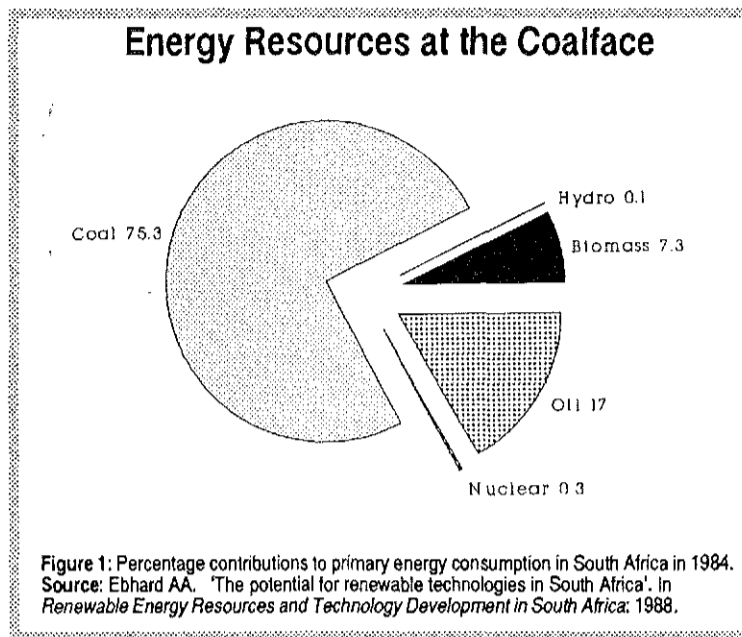


Figure 1: Percentage contributions to primary energy consumption in South Africa in 1984. Source: Ehard AA. 'The potential for renewable technologies in South Africa'. In *Renewable Energy Resources and Technology Development in South Africa: 1988*.

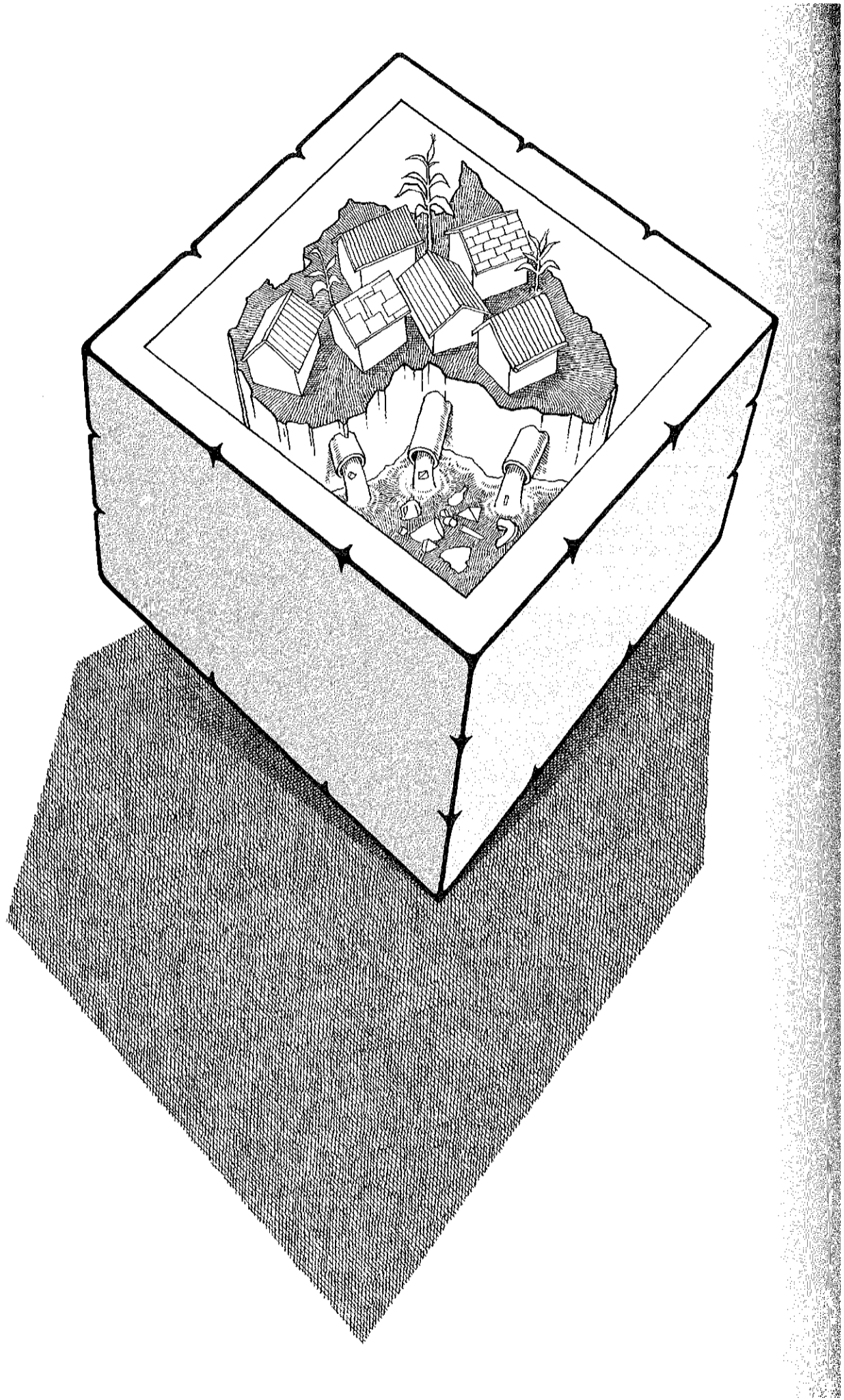
large-scale installations which may have adverse environmental impacts. Micro or mini hydro schemes suited for decentralised communities are often overlooked as an alternative. There is enormous potential for such small-scale schemes along the whole of the eastern seaboard of South Africa where runoff from rivers is relatively high.

Wind power is used extensively in this country for water pumping as is evidenced by the ubiquitous windmill, yet has never been a serious contender for the generation of electricity. This is not the case in Europe and North America. An estimated 1 500 MW of wind generated capacity are installed in the United States alone. Wind power, too, is well suited to a variety of applications in remote and windy areas.

Wave energy and energy from biomass are other forms of renewable energy with which South Africa is adequately endowed and which are awaiting exploitation.

Quite clearly, it is not a shortage of renewable energy resources which is inhibiting their development. Probably the single most important factor required for a change in emphasis is a favourable government energy policy. All countries which have successful renewable energy schemes have energy policies which favour renewable energy, either for intrinsic reasons such as the avoidance of pollution, or for the more pragmatic reason of ensuring self-sufficiency in energy supply. **IPQA**

Solar, wind, hydro, wave and biomass energy sources are worthy of exploitation in South Africa



Part 4 Overview

THE RAPE OF THE LAND

The term land has many meanings and is used to express social, political and even spiritual concepts. In its most fundamental sense, however, land is the soil and rock on which all terrestrial creatures live - it is where most of us build our homes and grow our crops, where we construct factories and extract minerals, and where we deposit much of the waste matter of our society.

The last few centuries of agricultural and industrial activity have taught us that land is fragile, and its recuperative properties, although often astonishing, work extremely slowly; damaged land can take centuries or even thousands of years to recover.

In global terms volcanic activity or fluctuations in sea level can add to or remove land from the total stock - a few years ago a volcanic eruption near Iceland produced the new island of Surtsey. The Maldiv Islands off the west coast of India are expected to disappear within fifty years, victims of presently rising sea level. But by and large the amount of land on earth remains constant, at least on a human time scale, such changes modifying it by an infinitesimally small percentage. Even land reclamation, although it may have localised beneficial effects, has little overall influence.

Rapid increases in world population mean that ever more people must be accommodated on a fixed amount of land. In Africa, with an annual population growth rate of 2,9%, the highest of all continents, land problems and issues are particularly acute.

In South Africa, nowhere are these difficulties more pronounced than in Natal, the most densely populated province. In places unwise and exploitative agriculture causes accelerated soil erosion, land degradation, declining yields and rising production costs. In urban environments the disposal of domestic and industrial waste in landfill sites can poison earth and water. Mineral extraction, especially from opencast mining, can completely alter landforms and change ecosystems, even after rehabilitation.

The following series of articles reviews some of these land uses from economic, social, ecological, technical, and legal perspectives. The contributors present a holistic environmental overview of some of the difficulties of land preservation which face society today.

Case Study 1

THE SOIL SPOILERS

Dr Gerry Garland

Department of Geographical and Environmental Sciences
University of Natal

Since the 1930s, when the first dust clouds from Oklahoma swept across America and the 'Great Dust Bowl' became a reality, the subject of soil erosion has given rise to much highly emotive, and at times alarmist comment. Events ranging from the creation of the Sahara Desert to the decline and collapse of the Roman Empire have all at one time or another been attributed to the scourge of soil erosion.

South Africa has not been immune to such sentiment. General Smuts once said that 'erosion is the biggest problem confronting the country, bigger than any politics', and in his book *The Rape of the Earth* published in 1939, GV Jacks claimed that 'soil erosion strikes at the very roots of South Africa's existence, and is the most urgent problem confronting the country at the present time'.

Strong stuff indeed, but when viewed from the perspective of the 1990s, such statements appear to be something of an over-reaction. Nevertheless, a trip around parts of the eastern Cape, Natal and Lesotho make it clear that there is a great deal of soil erosion. Its presence begs answers to a range of questions - what does it cost? - who is responsible? - what can be done?

Costs of Erosion

Because the economic consequences of erosion are not often evident in the short term of a few years or so, they may not be considered as particularly serious by agriculturalists. Added to this is the difficulty of converting the value of lost soil to rands and cents. As there is no

significant trade in soil *per se* it does not have a market value in the same way as other commodities, so any accounting procedure must make recourse to indirect assessments.

One approach is to estimate the value of plant nutrients lost as soil is eroded. This is possible because some nutrients are commercially available as fertilizers, and a realistic cost can therefore be assigned to them. On this basis, the nitrogen, phosphorus and potassium in one tonne of topsoil in the United States was estimated to be worth about US\$6 at 1980 prices. If this holds true for South African soils, then we may expect a tonne of local topsoil in 1990 to be worth at least R30. However, this estimate takes no account of the value of clays and organic matter, which give soil its structural stability and moisture retention qualities, trace elements present in tiny amounts but vital to plant development, and other important nutrients.

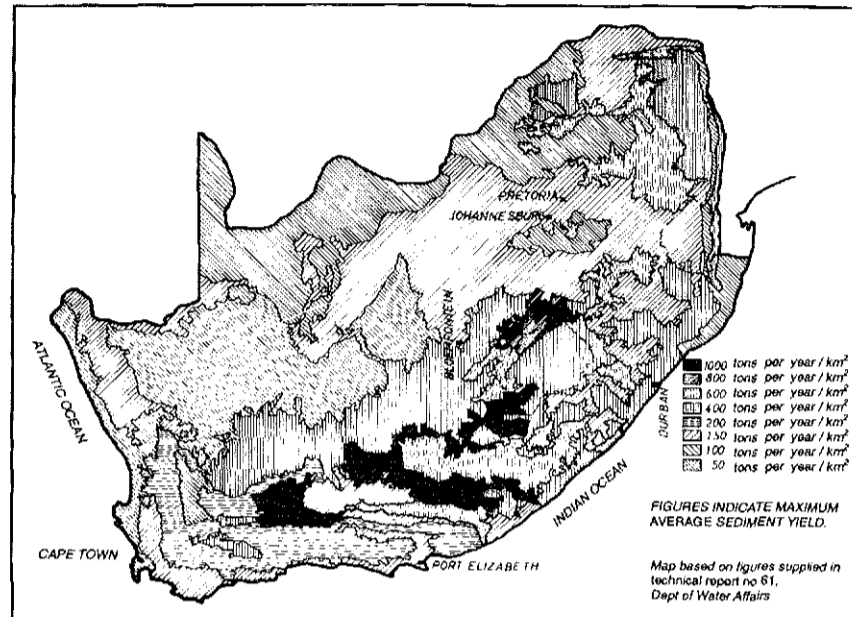
Alternative methods of costing are based on decline in crop yields. For example, an Australian study showed that the wheat yield declined by 4 kg ha⁻¹ for each mm of topsoil eroded, and was accompanied by a noticeable reduction in quality. Market value of land may also be used as a surrogate, in that land degraded by erosion can be bought for cheaper prices than land in good condition.

The point is, whichever way one looks at it, erosion costs money. Using the figure of R30 per tonne of top soil, the value of soil eroded from Natal's catchments each year is certainly not less than R500m, and could easily be three or four times this figure. In the Eastern Cape, with far higher soil loss rates, the amount could

General Smuts once said that erosion is a bigger problem in South Africa than politics!

The value of soil eroded from Natal's catchments can be indirectly estimated at perhaps R500m

South Africa's Annual Soil Deficit



Source: Rooseboom A Sedimentafvoer in Suid-Afrikaanse Riviere, Water SA, Vol4/No1: Jan 1978: 17.

There is a distinction between 'geologic' erosion and accelerated man-induced erosion

run into many billions of rands annually. Although the accuracy of these figures is disputable, the order of magnitude is probably close to reality. If one adds to them the costs resulting from silting of dams, where accumulated soil takes up expensive storage space designed for water, and other ancillary costs, then losses in rand terms must be enormous.

Soil Deficit

Obviously, all this would have little significance if soil were being replaced naturally at the same rate at which it is removed. Our understanding of rates of soil formation is poor, but we do know that it is a lengthy business. Research suggests that even under the most favourable conditions, with a rich, granular parent material, a warm, humid climate and a large biotic input, a soil profile would require at least thirty years to develop. On solid rock under less favourable weathering conditions hundreds, and perhaps thousands of years may be necessary.

To add 10 tonnes of soil to a square kilometre of land, even in the relatively rapid weathering conditions of Natal, probably takes years, if not decades. Some areas of South Africa lose well over 1000 t km² per year; parts of Natal lose in excess of 600 t km², and nowhere in the province is the figure less than 100 t km². The annual soil deficit is immense (see map).

Whether erosion can be reduced or not depends on many factors. Soil removal is a natural phenomenon which would take place irrespective of what course of action we choose to take. This natural component is known as 'geologic' or 'normal' erosion, as oppose to 'accelerated' or man-induced erosion. Geologic erosion can be quite high.

Some of the early travellers in Natal in the 1830s, long before extensive sedentary agriculture had become established, commented on the enormous gullies present in some areas. There can be little doubt that these gullies are the result of natural processes. From another perspective, calculations suggest that the rate of geologic erosion in the Tugela basin over the last 120m years is about 42 t km² per year.

Natural erosion results from the interaction of several variables, each exhibiting considerable variation from place to place, so that soil loss does not occur equally over the earth's surface. Should vegetation be absent in an area, then rates of soil loss are determined by *rainfall erosivity* - the ability of rain to bring into motion and transport soil particles; *soil erodibility* - a quality combining the characteristics of soil which make it susceptible to erosion; and the length and gradient of land slope.

The soils of Natal are not in general considered to be particularly erodible, although the province receives rainfall

which is amongst the most erosive in the country. This, together with the dissected topography and steep slopes makes Natal particularly prone to erosion under certain circumstances.

However a further factor of vital importance is *vegetation cover*, since vegetation absorbs much of the energy of rainfall and reduces and retards surface runoff. Further, it is the variable most easily influenced by man, since agriculture of any kind implies modifying the vegetation of an area in some way. Often this takes the form of reducing vegetal cover both spatially and temporally, leaving soil exposed and unprotected for certain periods of the year.

For this reason, productive agriculture will always increase erosion rates over and above geologic soil losses. In a given area with constant soil, slope and rainfall conditions, the magnitude of this increase will depend on the type of crop and the way in which it is grown. Some crops provide much better soil protection than others. Pasture, if it is not overgrazed, forms a dense, protective mat over the soil surface; sugar cane, because of its thick foliage, and the fact that it is not replanted every year, is also a good protector; wheat is not.

It is the manipulation of some of these variables which offers the key to the minimisation of erosion and development of soil conservation techniques. Broadly speaking, agronomic measures for conservation include modifying the way a particular crop is grown and/or the way it is harvested, thereby controlling to a degree the vegetation variable. The type of crop rotation used, the decision to leave crop residue on fields after harvesting, or to employ minimum tillage techniques prior to replanting are all agronomic practices which can be quite effective.

Leaving trash on the ground after harvesting can reduce soil losses by between 800% (bananas) and 100% (sugar cane). In Zimbabwe, a six year rotation of tobacco : grass : grass : tobacco : grass : grass, was more effective in reducing erosion than tobacco : tobacco : grass : grass : grass : grass, since grass, the conservative crop, has a beneficial residual effect on soil stability, even when it is removed.

Mechanical conservation techniques are those that in some way alter the land surface. In particular they attempt to change slope length and gradient in order to reduce the power of surface runoff to erode. Contour ploughing, the simplest of these, can reduce soil losses up to 50%, depending on slope and rainfall conditions. Bench terraces, which have the appearance of horizontal steps cut into a hillside, can save huge amounts of soil, but are expensive to build and maintain, and limit the use of agricultural machinery.

It is also possible to improve the resistance of soil to erosion. The addition of organic material like manure or ploughed in crop residue will improve soil structure, increasing cohesion and soil moisture retention. Reduced application of fertilizers rich in monovalent salts can prevent the breakdown of soil structure and cohesion.

The only variable in the soil erosion system over which we have almost no control whatever is rainfall erosivity, although as cloud seeding technology develops even this may one day fall within our grasp.

Environmental Problems

Technical solutions to most soil erosion problems are available, and soil losses could certainly be significantly reduced, if not to normal levels then at least to manageable volumes. Why then does the phenomenon remain such an economic and environmental problem? There is no simple answer. In some areas the types of crop grown are unsuited to agricultural conditions. In others too many people depending on subsistence or small-scale agriculture have been crowded on parcels of land so small and steep that use of conservation measures is impossible in practical terms.

However, one of the major difficulties lies in persuading farmers to adopt conservation friendly techniques. Many agriculturalists are loath to implement measures that are expensive and cannot be shown to be cost-effective in the short term. Others raise cultural objections. Farmers in a small area in south eastern Nigeria refused any attempt to arrest gullying, which they thought was a punishment from the gods, because they

Productive agriculture will always increase erosion rates over and above geologic soil losses

Soil conservation techniques include crop rotation, mulching, contour ploughing and organic manures

One of the major difficulties is to persuade farmers to adopt conservation-friendly techniques

believed that interference would only invoke further divine retribution. In other parts of the world de-stocking to reduce overgrazing is resisted since wealth and status are measured by the number of beasts a person owns, irrespective of their condition.

Another difficulty has emerged from a study by the International Federation of Institutes of Advanced Study, using Nigeria, the Philippines, Colombia and Peru as its base. In these areas many farmers did not recognise symptoms of erosion like gullies as evidence of agriculturally related erosion. They realised that land fertility was falling along with crop yields from year to year, but few, if any, ascribed this to cumulative soil loss. Such attitudes were unrelated to fundamental educational attributes like literacy, suggesting that the solution does not lie simply in elementary education.

Whether the soil conservation lobby, so prevalent over the last fifty years, has had much success in South Africa is difficult to judge. Certainly, sediment yield - a fairly good indicator of catchment erosion under most conditions - of many of the country's main rivers has diminished in the last few decades. However, many experts ascribe this less to the success of soil conservation schemes than to the fact that erosion has been so severe in many catchments that there is now hardly any soil left to erode. In general there is little evidence to show that improved agricultural techniques have effected a noteworthy reduction in soil losses.

Solutions

Erosion may not yet be so severe that it is ready to destroy the very fabric of the country, but it is a costly agricultural and environmental problem, and on a local scale can degrade land to the point where it becomes completely unproductive, imposing intolerable stress on local communities. For it to be brought under control we need a better understanding of the relationship between geologic and accelerated erosion, and far more information on rates of soil formation. But more important is the development of successful soil conservation strategies.

Worldwide experience in underdeveloped regions has produced certain guidelines which seem to determine the degree of success of any conservation scheme. First, it is important that the local community is made aware of the perils of soil erosion, taught to recognise the symptoms, and given the opportunity to become involved early on in the conservation planning stage. In this way conflict between new approaches and techniques, and local culture and tradition can be avoided, or at least minimised.

If it is necessary to introduce a new crop or cropping system, or a different scheme of soil management, then it must result in increased income to the farmer in the year it is introduced. Farmers must, through demonstration, be given the opportunity to see this for themselves. In order to ensure success, it may be essential to introduce a system of subsidies and payments for implementing conservation procedures.

A force of qualified and well trained extension officers, preferably drawn from the local community, and with all necessary bureaucratic, financial, technical and infrastructural backup must be appointed. Their task is partly educational, but they must also have the know-how to design conservation schemes, and above all have the authority to approve bank credit, and authorise and expedite payment for completed conservation works.

No payment should be made to farmers for conservation work they have undertaken to do until it is completed, and has been approved by an extension officer. Finally, the scheme management must ensure that all necessary inputs in the form of equipment, materials, fertilizers and so on are available at the times of year that they are needed.

The world is littered with highly structured, well-financed and technically excellent conservation schemes which have been partial or total failures, because these simple principles have been ignored. The more closely they are satisfied, the better the chance of success.

Worldwide experience in less developed regions has produced certain guidelines for conservation success

Case Study 2

SOCIETY'S WASTE STREAM

Ray Lombard
Department of Civil Engineering
University of Natal

During the last decade waste management in the world has changed dramatically, largely in response to a number of unfortunate incidents. The Love Creek Canal problem in Niagara Falls County (USA), the Redhill cyanide deaths in Surrey (UK), the dioxin fallout contamination around Serveso (Italy), and many others were all environmental disasters of the worst kind. These incidents made it clear that existing systems of toxic waste management were inadequate.

The development of a waste management system cannot proceed in isolation as it is intimately related to any country's financial position, its resources, the socio-economic level of its people and its potential for industrial growth. The vulnerability of the local environment, the quantity and types of waste generated, and the attitudes of the people all increase the complexity of the problem. South Africa has its own unique scenario. It is a land rich in minerals, but poor in water resources. Its climate varies from wet to dry across the country, and its demography identifies it as a developing country.

Population Growth

South Africa's population of almost 36m is set to double within the next thirty years, with most growth expected to take place in urban areas. Rapid urbanisation places heavy demands on the country's resources, and the allocation of funds to services as menial as waste management is severely constrained, limiting available options considerably. Further, in order to support a burgeoning population more jobs must be created, a high economic

growth rate is essential, industrial activity must expand, standards of living will rise and more waste will have to be managed in the densely populated parts of the country.

Both formal and informal settlements are present in developing urban areas. These are often overcrowded with population densities ranging from 8 500 to 39 000 people km². This situation is exacerbated by the large annual influx of people into many of these areas, resulting in urban growth rates up to 9% per annum, and occupancy levels from 7 to 16 people per dwelling.

Many formal urban areas have substantial backlogs in the provision of basic infrastructure like housing, social and public health services. Waste management is given a very low priority in the hierarchy of needs perceived by developers, and is consequently under-resourced, yet the residents rate public health services, including waste management, as high priority needs. Often, the majority of households have inadequate waste storage capacity; collection and disposal services including street sweeping are virtually non-existent. The associated health risk and environmental degradation is unacceptable.

There are more than 28 established local authorities in the PWV region; 90% of these are administered by elected local councils, while the rest of these are managed by appointed administrators. In addition squatter areas abound, increasing by over 1,5m the official population estimates for formal local authorities of 3,58m.

Environmental disasters such as Serveso and Redhill have made the dangers of toxic waste management clear

Waste management is given a low priority in the hierarchy of needs perceived by developers in poor countries

Not all industrial wastes pose a threat to the environment, and many waste materials may be recycled

The Durban Functional Region has 33 formal and informal settlements. The KwaZulu government administers most of the formal urbanised areas through elected councils and appointed officials. The Inkatha Institute estimates that the formal developing areas house approximately 0,65m people, whilst the informal zones may accommodate as many as 1,7m.

wastes pose a threat to the environment and many waste materials have value, depending on the cost of recovery and market value after extraction.

A particular area of concern is the hazardous and toxic component of the industrial waste stream. Its complexity must be categorised and quantified in order to deal with it effectively.

**TABLE 1
INDUSTRIAL WASTE**

The scope of the solid waste problem is amply illustrated by the following estimates:

CATEGORY	WASTE (millions of tons per annum)	
mining industry	200	
electricity generation	20	
primary chemical industry	N/A	
urban solid waste		
• domestic/trade waste	11,8	
• industrial waste	4,0	
• hazardous waste	0,2	= 16
sewage/water treatment sludge		4
TOTAL		240

Urbanisation and the associated consumption of goods and energy increases the waste problem

Urban solid waste originates from domestic activities, commerce, secondary industrial operations, and littering. It includes sewage, domestic refuse, secondary industrial waste and packaging material. Litter alone may be subdivided into paper board, paper, plastic, tin-plated steel cans, glass, other re-usable materials, and a residual unusable fraction. Most of this waste is landfilled, very little is re-cycled and the balance is either littered or disposed of illegally.

Industrial waste covers a wider spectrum of material including many chemical compounds. Some wastes are derived from primary industry and are handled by the industries themselves. Wastes such as pulverised fuel ash, metalurgical slags and phosphogypsum are produced in quantity and disposed of in large open dumps. Some recycling takes place, but it is limited in extent.

Waste from smaller industries is generally dealt with by local authorities and private contractors. Wastes from abattoirs and the food processing industry are rich in protein and are extensively recycled. Not all industrial

Mining waste includes a host of slimes, sludges, tailings and waste rock resulting from the beneficiation process. Large quantities are disposed to dumps which represent unattractive landforms. The major threat posed by these wastes is that of increased salinity in local water supplies. The reprocessing of dumps and backfilling of discarded material is general practice. The field is well-researched and appropriate measures have been prescribed to cope with most of the expected problems.

The magnitude of the urban solid waste problem is expected to increase as:

- population growth places pressure on the ecological carrying capacity;
- statisticians predict that 80% of the population of South Africa will be urbanised by the turn of the century. This means that some 47m people will be living in areas that are already densely populated;
- urbanisation of rural people leads to aspirations of First World affluent life-styles, and the associated profligate consumption of goods and energy. Improvement in the standard of living inevitably results in more waste.

Disposal Technology

The standard of waste disposal technology is low throughout southern Africa, particularly in smaller local authorities. The pending regulations drafted in terms of Section 24 of the Environmental Conservation Act (Act 3 of 1989) will do much to improve the situation, because waste disposal organisations will be forced to allocate more money to achieve high standards in waste disposal sites and technology.

In many areas the unsatisfactory principle of 'best practical means' is still applied because high level disposal standards are not 'affordable'. However the experience of countries in the Developed World contradicts this attitude, promoting the acceptance of stringent waste management legislation and the principle of the 'best environmentally practicable option' now applies.

The planning of future waste disposal sites requires a much higher priority on the agendas of local authorities. The sites must be located in acceptable geological and soil formations, avoid vulnerable aquifers and surface water, and minimise environmental impacts. Suitable disposal sites in high density residential areas are already a problem.

The answer lies in the identification of regional disposal sites and their operation at high standards. Such sites may, as has already been demonstrated in the PWV area, lead to savings in system costs of up to 30% for the entire region, despite increased local transport costs.

A broad spectrum of waste produced in South Africa is hazardous to human, animal or plant life. These wastes interact with the environment on a chemical basis. Therefore they are classified into different categories depending on their chemistry and other inherent characteristics. Different disposal procedures and control measures apply to each category.

The sources of these wastes are major industries including chemical, petroleum, mining, nuclear, metallurgical, medical and manufacturing, as well as local authorities. The lack of accurate data is a serious shortcoming for this group of

wastes, and as a result control remains general and reactive rather than specific and proactive. The spillages of hazardous waste substances on our highways are but a symptom of the entire malaise. 'Cradle to grave' control such as is practiced in the UK, is urgently required.

Recycling Waste

The extraction of material from the waste stream and its utilisation in various ways is commonly termed 'recycling'. This is practiced for many reasons, including financial gain, energy conservation, litter abatement, reduction of the waste stream itself and of potential pollution.

The low technology recycling industry in South Africa is represented by the well-developed paper, scrap metal, plastics, glass and rubber industries. The markets for these recycled materials have fluctuated severely in the past, making these high-risk enterprises. High technology recycling takes place in South Africa only on a small scale, and involves composting, energy recovery and chemical brokerages.

Waste disposal is costly when performed at acceptable standards. The recovery of materials from the waste stream also incurs cost and increases the total cost of waste management. Consequently, resource recovery is only viable when the cost of the recycled product is less than or equal to that of new material. There is still prejudice against so-called used material.

Unless there are sound strategic considerations relating to scarce or embargoed materials, market forces and not legislation should determine the extent of resource recovery. The hidden costs and benefits of recycling, especially the long-term environmental and social benefits, will have to be considered when policy decisions are taken.

Solutions

The driving force for change in this industry is based on regulations within existing legislation, and on a strategy to introduce this to all concerns. This calls for an extension to existing regulations in order to include hazardous and toxic wastes. A formal regulation structure is also required to ensure that, on the basis

The standard of waste disposal technology is low throughout Southern Africa

The planning of waste disposal sites requires a much higher priority from local authorities

Unless there are sound reasons, market forces and not legislation, should determine waste resource recovery

of good local control, imported wastes should be clearly identified. An appeal should be made to the authorities to prevent these wastes from entering this country.

There are strong indications that Africa as a continent will come under increasing pressure to act as the disposal ground of the First World. If this is allowed to get out of hand not only will the future of many typically African ecosystems be threatened, but long-term pollution of the continent may be irreversible. The enforcement of control over waste and waste disposal in the developing areas is a delicate topic. Economic imperatives and political backgrounds are such that there is not much scope for drastic action.

The development of new technologies, the dissemination of tried and tested technology and their application in South Africa is a major challenge to research locally. Waste management is a multidisciplinary field and development is taking place on many fronts.

The most avant garde area of research is currently bio-waste technology. Industrial effluents and leachates from landfill sites are prime raw materials to be treated aerobically to produce methane, single cell protein and other products. The recovery of methane from landfill sites is an economic reality in South Africa already. Microbial destruction of harmful wastes is receiving much attention overseas.

In the decade of computerisation there are many computer models available to assist decision-makers in projecting data into different scenarios. These are not widely used in South Africa due to ignorance of their power, and the fact that they were developed for much more complex First World situations.

The development of control measures for waste management and appropriate technologies, and the application of both in the context of the typical South African situation is a challenge that cannot be neglected. All parties have to cooperate and efforts must be coordinated. It is a matter of enlightened self-interest that the reduction of the volume of the waste stream should enjoy a much higher priority than at present.

The municipal system produces a waste stream that becomes irretrievable after disposal, but material can be collected anywhere between the point of generation and the point of disposal. For this to become a reality the following issues must be addressed:

- the extraction of material from the waste stream whether at source, transfer station, depot or landfill site;
- the coordination of activities between private and public sectors;
- the instability of recycled markets;
- the creation of public awareness; and
- establishment of a data base on the generation rate as well as the composition of the waste stream.

Options that are specific to each individual sector must be evaluated individually. In many cases hazardous wastes may be eliminated from the waste stream altogether through appropriate process selection.

In conclusion, the objectives of waste management in South Africa must be: to optimise the use of resources; to add value to waste and introduce a spirit of conservation; to reduce the waste stream and extend the life of landfill sites; to save energy; to encourage the establishment of small recycling enterprises and to provide more job opportunities. **IPWA**

There are strong indications that Africa will come under increasing pressure to act as the disposal ground of the First World

Environmental Strategies OF MINES & MEN

Jeremy Ridl
Associate of the Institute for Environmental Law
University of Natal

Mining plays a key role in the national economy of South Africa as one of its largest and most important industries. As with all of the country's natural resources, policy for the exploitation of minerals lies firmly in the hands of the state. Within the framework of a state monopoly of mineral rights, private enterprise exploits the mineral resources for the mutual benefit of itself and the state.

Historically, the state has encouraged the search for and exploitation of the considerable mineral wealth in South Africa. It has done so through a plethora of enactments which reward and protect private enterprise on the one hand, whilst controlling the mining activities on the other, ensuring, at the same time, that the state shares in the profits to be derived without bearing any of the attendant risks. This philosophy pervades all of the relevant legislation under which mining rights are obtained and exploited.

Limited Protection

Mining can, and often does, have a very damaging impact on the environment. This has undoubtedly been recognised by the legislators but appears to have been of tertiary concern after a predilection for control and the pursuit of maximum profit. Furthermore, in the mining statutes, policy regarding the protection of the environment is left for determination by the State President (through his Ministers) in the form of regulations made on an ad hoc basis. From an environmental point of view, this is unsatisfactory since such

legislation (and the regulations which follow under it) is made without reference to any stated or general policy for the environment.

State recognition for a definitive policy for the environment is very recent and its implementation in its infancy. The Council for the Environment was established in 1982 in terms of the Environment Conservation Act (100 of 1982). Its object is to advise the Minister of Environment Affairs on environmental policy and on the co-ordination of all actions directed at or liable to have an influence on any matter affecting the conservation and utilisation of the environment. From the time of its establishment, the Council has addressed the need for an overall policy and strategy for the achievement of environmental goals in South Africa.

Whilst the establishment of the Council and its objectives are positive steps one cannot expect any immediate effect upon mining legislation or immediate benefit to the environment. Damaging mining practices will continue to be controlled by existing mining legislation which has limited protective measures for the environment. Similarly, the Environment Conservation Act, as will be seen, is at present of little assistance to those concerned with the protection of the environment when faced with the threat of mining in an area which has high conservation value.

In terms of the Mining Rights Act (20 of 1967) the right to prospect for, mine and dispose of all minerals (other than precious stones which are covered by

Imposing few controls, the state encourages the private sector to explore for and exploit mineral wealth

An official environmental policy has emerged only recently, and its implementation is in its infancy

The procedure whereby mineral rights are obtained and exploited has a major environmental weakness

similar provisions in the Precious Stones Act (73 of 1964) vests in the state. However, this does not confer upon the state dominion of the right to the minerals but merely control to a greater or lesser degree.

The environmental implications are not dealt with specifically in the Act. Measures protective of the environment are contained in regulations promulgated by the Minister under the Act and may also be embodied in specific conditions attaching to the mining lease.

From an environmental point of view, the procedure whereby mineral rights are obtained and exploited has one inherent weakness: a prospector having discovered minerals in viable quantities and having satisfied the Minister as to his financial ability, is, as of right, entitled to a mining lease. The Minister is left with an ability to impose conditions upon the mining operation but not to prevent it, even if the consequences for the environment are potentially disastrous.

In theory, under present legislation, if the Minister wishes to prevent any mining which may have consequences so serious for the environment that he deems it preferable not to allow the mining to take place, he must reach that decision prior to granting a prospecting permit to the applicant. In practice, that simply does not occur.

To reach such a decision, the Minister would have to call for detailed environmental impact studies prior to the granting of prospecting permits and before it is known what minerals occur and in what quantities. That would obviously involve considerable expense before it is known whether minerals exist in any viable quantities or at all. Consequently, the legislation in its present form, and because of its practical application, does not guarantee the implementation of sound environmental policy in connection with mining operations.

Environmental Impact

Before one considers the necessity of curtailing mining operations where they are potentially harmful to the environment, one must consider what harm may occur. The more serious

consequences of mining are the following:

• Pollution

Gold mining, in particular, has caused much pollution by water emanating from slimes dams and other mine workings. In the case of certain gold mines, the acid content of the water which causes pollution is produced as a result of the chemical action of air and water on the iron pyrites naturally in the ground. The damage caused in such cases may involve contamination either of soil and water on the surface or of underground water supplies.

Surface water has been polluted by the escape of acid-bearing water flowing from slimes dams in which there are cyanide compounds which are difficult to neutralise. Contaminated water has entered river systems (such as the Vaal) and has caused the destruction of the biological and hydrological eco-systems of the rivers and their tributaries. Further, finely ground siliceous and pyritic material causes the occurrence of white clouds of dust on windy days, originating from the surface of dry slimes dams and resulting in dangerous silica dusts enveloping towns and private dwellings.

Coal mining has also contributed to damaging the ecology of our public streams which have been contaminated by acid and other leached out salts. A further nuisance is sulphurous fumes emanating from burning waste dumps. These, in addition to having an obnoxious smell, also combine with atmospheric moisture resulting in corrosion damage to buildings and steel structures.

Where roasting and combustion processes are carried out, atmospheric problems arise from fumes and smoke. Such conditions can affect vegetation, agricultural crops, streams, buildings and often the inhabitants of the area concerned.

• Geo-hydrology

The abstraction of both ground water and surface water has had a serious impact upon the natural functioning of the geo-hydrology of certain areas. The introduction of water during the process known as dredge mining (such as that employed on the North Coast of Natal in the titanium mining process) has a

Having granted a prospecting permit, the Minister may impose conditions but not prevent any mining operation

potentially serious impact upon the functioning of the ground water systems and the wetland systems adjacent thereto.

• *Aesthetic appeal*

Mining, by the removal of vegetation and in some instances the creation of mine dumps, slimes dams, rock dumps and spoil heaps are aesthetically damaging to the natural environment.

• *Loss of habitats*

By the removal of vegetation there is a loss of habitat for numerous species of plant and animal life which in turn has a serious impact upon the functioning of entire eco-systems.

• *Infrastructure requirements*

The infrastructure necessary to support most forms of mining is often more harmful to the environment than the mining itself. Dune mining, for example, has enormous requirements of both water and electricity. That means the abstraction of vast quantities of water from nearby supplies and storage in dams which emerge the surrounding areas and its transport in canals and pipelines (the construction and maintenance of which have a considerable impact on the surrounding areas). Likewise the overhead cables and pylons by which they are supported destroy the aesthetic appeal of the areas over which they pass. So when one considers what the impact of mining will be, one must look further than the mining operation itself.

Clearly, therefore, mining is an activity which is seldom undertaken without serious implications for the environment. The imposition of restraints upon mining and its methods are clearly justified. The protective measures are, however, sadly inadequate. What is required is some substantial amendment to existing legislation, incorporating the principles of a national policy for the environment.

Integrated Management

The Council for the Environment has developed a process known as Integrated Environmental Management (IEM). It is a procedure for guiding developments of all types. Its objective is to integrate environmental considerations into all stages of the development process in order to achieve the benefits of

development with minimal harm to the environment.

The IEM procedure consists of four stages that run parallel to the normal stages of development. They are:

- careful planning of new developments;
- an efficient process of assessing the environmental effects of developments;
- an open and accountable decision-making process; and
- enforceable programmes to reduce the harmful effects of development on the environment.

Although the IEM procedure is not mandatory, there is no reason why it cannot be made compulsory under the Environment Conservation Act. The Act empowers the Minister of Environment Affairs to do so either in the form of a determination of policy or by regulation. There is an urgent need for the Minister to do so without further delay.

The proper implementation of the IEM procedure would more or less guarantee the wisest possible use of our natural resources. Decisions would be based on the best (or at least adequate) information and the public would have the opportunity of participating in the decision-making process. If the final report has passed through the independent review stage by a properly constituted and qualified committee, then the Minister in making a decision will be guided by the advice of unbiased experts best able to determine the acceptability of any development proposal. A recent survey amongst South Africa's business leaders and professional ecologists has found that both are in favour of compulsory environmental evaluations as part of the development process.

Businessmen also prefer certainty in the law. Finding environmental legislation, let alone understanding its implications for a particular activity, is no easy matter. It is scattered throughout numerous statutes, regulations and provincial ordinances. Matters were improved when at last in 1982 protection of the environment was given the recognition it deserved in the form of the Environment Conservation Act (100 of 1982). However, recognition was about all it received.

The Act had very little effect on developments and probably no effect on

The infrastructure which supports most mining operations is often more harmful than the mining itself

Substantial legislative amendment is needed, incorporating the principles of a national environmental policy

A survey of business leaders and ecologists shows they are both in favour of compulsory environmental evaluations

mining. The Act was improved considerably in the 1989 version but still remains somewhat toothless. The so-called 'Coastal Zone Regulations' promulgated under the 1980 Act (and saved in the 1989 Act) gave a measure of protection to a strip of land 1 000 metres wide adjacent to the seashore. It prohibited a list of activities without a permit having first been obtained from the Administrator (of Natal or the Cape). The list is wide enough to include most activities (including mining) which have an impact on the environment.

Restricted Powers

The 1989 Act makes provision for both the prohibition of activities and the setting aside of areas as protected or limited development areas and as nature reserves. However, the Minister's power to prohibit activities is severely restricted by the requirement that before he identifies any activity as being likely to have a detrimental effect on the environment, he is obliged to consult with the Council for the Environment, the Administrator of each province, and to obtain the concurrence of the Minister of each Department of State responsible for the control of the activity concerned, and of the Ministers of Environment and of Economic Affairs and Technology.

Under the improved 1989 Act, the Minister's power to prohibit mining activities is still severely restricted

In short, protection of the environment is subservient to virtually all other activities. It is of no comfort to conservationists to have environmental policy in the hands of virtually every government Minister. A survey conducted by the Wildlife Society of Southern Africa just before the September 1989 elections revealed an alarming lack of interest in and knowledge of the environment by all but a few candidates in the election (none of whom became cabinet ministers!).

The logic of such a provision in the Act is all wrong. It is the Ministers of all Departments of State who should be obliged to seek the concurrence of the Minister of Environment Affairs before allowing any activity under their control to take place. The serious degradation of our environment and the depletion of our natural resources demands that concern for the environment be placed before economic development. Activities which cannot be carried out without seriously

harming the environment irreparably, should simply not be allowed. A healthy environment is vital to sustain continued economic development; so it is not the demands of the 'eco-freaks' and 'armchair conservationists' which require this but plain common sense and foresight.

The Minister of Environment Affairs has not yet passed any regulations under the present Act necessary to give the law any teeth. He is probably realistic about his chances of having his brothers in the Departments of Finance, Trade and Industry and Mineral and Energy Affairs concur with him in placing restrictions on an activity (such as mining) which is responsible for a large slice of the state's income.

St Lucia Lessons

St Lucia's story is a classic illustration of the deficiencies in our legislation and the government's indecisive policies on environmental issues.

The St Lucia region (which spreads from the Mkuze Game Reserve and Sodwana Bay in the north to the Umfolozi Game Reserve and Mapelane in the south) is internationally recognised as a natural area of great conservation value. South Africa, as a party to the Ramsar Convention, has undertaken to preserve it. It has an extremely rich biotic diversity because of the variety of habitats it abounds.

Lake St Lucia is the largest estuarine system on the African continent. Despite its great value as a complete eco-system, government policies have precipitated:

- tsetse fly control measures which involved the mass destruction of wild animals and the widespread spraying of the now banned DDT;
- the introduction of extensive commercial timber plantations (some 22 532 ha);
- bad agricultural practices;
- poor catchment management (a threat to the fresh water supply essential to sustain the lake system);
- a missile testing range in a wilderness area; and
- dune mining.

All of these activities have been allowed despite the obvious threat posed to the

continued existence of Lake St Lucia and its environs. All for what? Economic benefit. (Arguably, even the missile testing range was established in this region for economic reasons as the land was already state-owned and the need to acquire land specially for this purpose was avoided).

Public concern became public outrage when the proposals to mine the eastern shores of Lake St Lucia were revealed. Were it not for the massive opposition to the proposed mining, it is likely that the necessary mining lease would have been approved by the end of September 1989 and mining would have commenced some time in 1991. However, the public has achieved no more than a stay of execution for the present because the government has not done any of the three things that it must do if mining is to be prevented and the area given permanent legal protection. They are:

- the implementation of the policy contained in a statement released by the Department of Environment Affairs in 1983 which provides for the protection and management of the St Lucia region;
- the passing of regulations necessary to give the Environment Conservation Act some efficacy and certainty in its application; and
- the declaration of the area as a protected natural environment.

Unfortunately, the public cannot look to existing legislation for much assistance in

their continuing campaign. If there is a remedy, it will be political rather than legal.

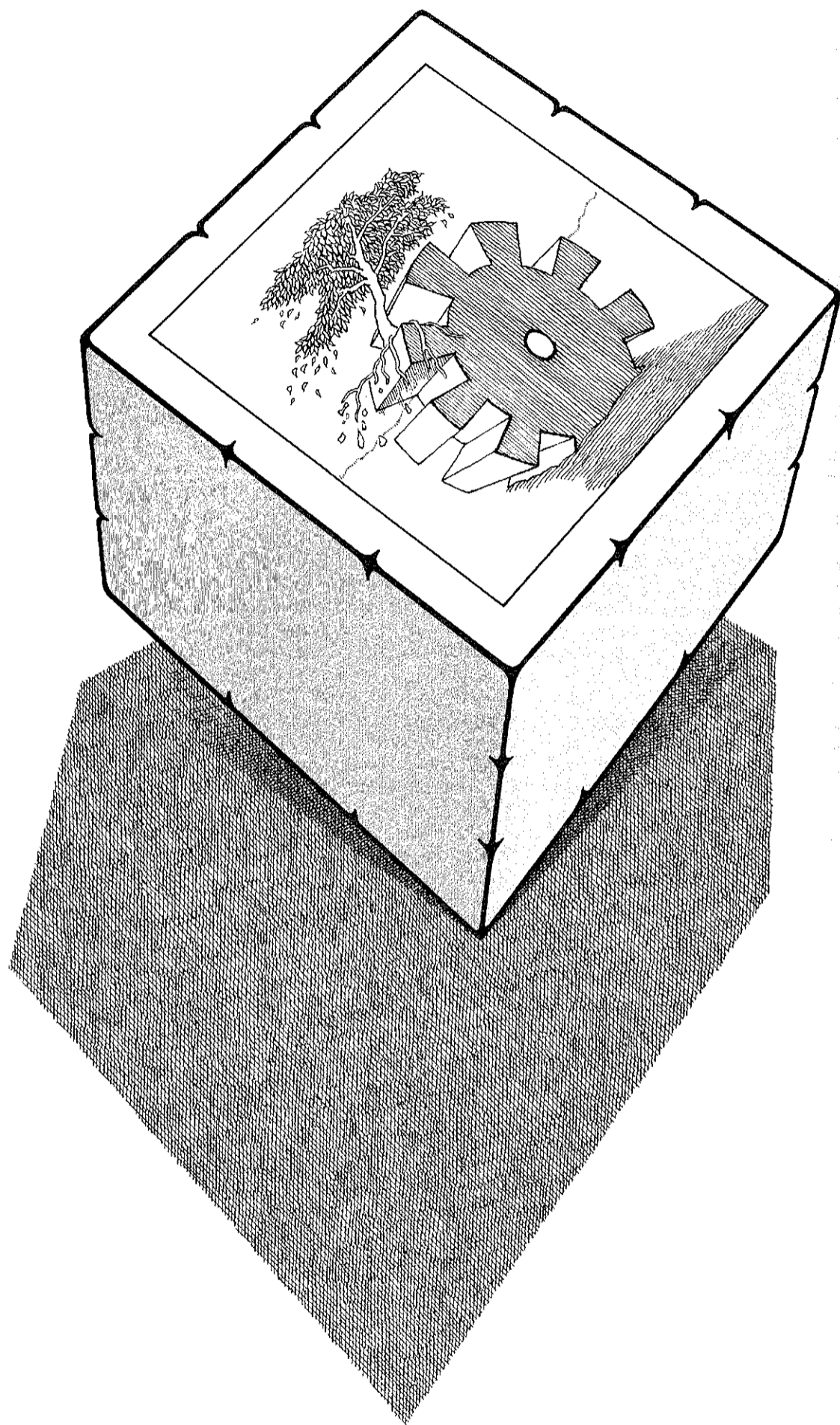
As matters stand at present, the future of our environment is not in safe hands. What is required is a sound national policy for the environment which should be implemented through effective environmental legislation.

Concern for the environment should be taken into account in all legislation not directly involving the environment but which controls those activities which do impact upon the environment. The United States of America has its National Environmental Policy Act of 1969 (NEPA) which provides for national environmental policy and for the integration of environmental criteria into major development proposals. The Act makes the federal government subservient to the law in that it is required to include a detailed statement of the environmental impact of its own proposed actions if they are likely to significantly effect the environment.

It is all a matter of getting one's priorities right. In South Africa, our policy and law makers must take a long and hard look at the legislation and policies they have fathered, and they must do so without delay. The problems facing our environment must be confronted today - to leave them for the next generation is too late. **DEPA**

The depletion of our natural resources demands that environmental concerns be placed before economic development

The US Environmental Act makes the federal government itself subservient to legal controls



Part 5 Overview

FROM RESOURCES TO RICHES

INDUSTRY AND THE ENVIRONMENT

One of the important lessons we have learnt in recent years is that progress from resources to riches is not simply a matter of identifying resources and then exploiting them. Wise resource management balances the need for goods and resources against environmental disruptions.

Mining an ore, felling a tree or damming a river have important economic and ecological consequences which can be measured in terms of benefits and costs. However, the issue is not simply an economic one. At some point society should intervene, through the political process, to indicate what balance of benefits and costs is acceptable in the process of resource development, who gains and who loses, and whether compensation should be allocated.

The complexity encountered in resolving the environmental Rubik cube problem is daunting. For this reason, many environmental problems have quietly been placed on the shelf of political non-decisions in the past. This form of decision-making is no longer tenable.

*It is interesting that the words ecology and economics are derived from the same Greek root, *oikos*, meaning house or home. Ecology studies the interaction between species in our earthly home; economics is broadly concerned with 'household' management. The linkage between the two is the purpose of this section which contains private sector contributions on environmental management strategies.*

The literature is replete with examples of environmental insensitivity on the part of manufacturers, resources extractors, developers and government. However, we now find increasing evidence of public interest groups, resource developers and government giving consideration to both ecological and economic aspects. Examples are outlined in this section:

- the first two cases studies develop the debate for and against dune mining in the St Lucia area of Natal;*
- the third and fourth case studies explore the environmental attitudes and concerns of aerosol and paper manufacturers; and*
- the final article outlines the need for environmental education and documents a specific example of an industrial environmental programme.*

Case Study 1

THE CASE FOR DUNE MINING

Roy MacPherson
Managing Director, Richards Bay Minerals

Richards Bay Minerals (RBM) was re-established in 1976 to extract and process the valuable minerals occurring in the coastal dunes north and south of Richards Bay. The company's major product, titanium slag, is an essential raw material for the production of titanium pigment which is used internationally in the manufacture of paints, plastics, printing inks and paper.

Environmental planning has been an integral part of the mining operation since its establishment thirteen years ago. The company recently won the EPPIC (Environmental Planning Professions Interdisciplinary Committee) award for excellence in environmental management and its ongoing dune rehabilitation programme has been acclaimed by notable conservationists such as Dr Ian Player, the Minister for the Environment, members of the Natal Parks Board and the Wildlife Society. Two full-time ecologists are employed to administer the rehabilitation programme and to liaise with environmental organisations.

Dune Rehabilitation

The mining process is simple and environmentally benign. It does not require the use of chemicals or reagents. Ponds are created in the ore-bearing dunes and minerals are removed by pumping sand and water through floating gravity separation equipment. RBM currently has three mining plants in operation, each covering an area of 50ha at a time. The vegetation in advance of each dredge pond is cleared prior to

mining and, as each mine moves through the dunes, the mined sands, constituting 93% of the original material, are deposited at the rear and reformed to restore the original dune topography as closely as possible (see figure 1).

The present rehabilitation policy laid down by the KwaZulu authorities who own the land, is to replant the mined area with the vegetation which occurred before mining - one-third indigenous forest along the coast and two-thirds commercial plantations inland. Although different methods are used, the cost of restoring the land to indigenous forest is the same as replanting commercial forest - about R15 000 per ha.

The first step in the rehabilitation to indigenous species is to spread the seed bearing topsoil taken from the front of the mine, over the reformed dunes behind the mine. Shadecloth windbreaks are then erected and a cover crop of grasses and cereals is sown mechanically. The cover crop of grasses and cereals is sown mechanically. The cover crop grows quickly, protecting the slower indigenous seeds from the high soil temperatures and the strong winds. After 18 months the cover crop dies and the indigenous vegetation takes over. Within five years, dense vegetation covers the dunes and after ten years the forest takes on the appearance of natural forest containing numerous different indigenous species.

RBM's oldest rehabilitated indigenous forests are now 13 years old. Already they contain 175 different plant species

Environmental planning has been an integral part of RBM mining operations since the company's establishment

The dune mining process is simple, carefully monitored by company ecologists and environmentally benign

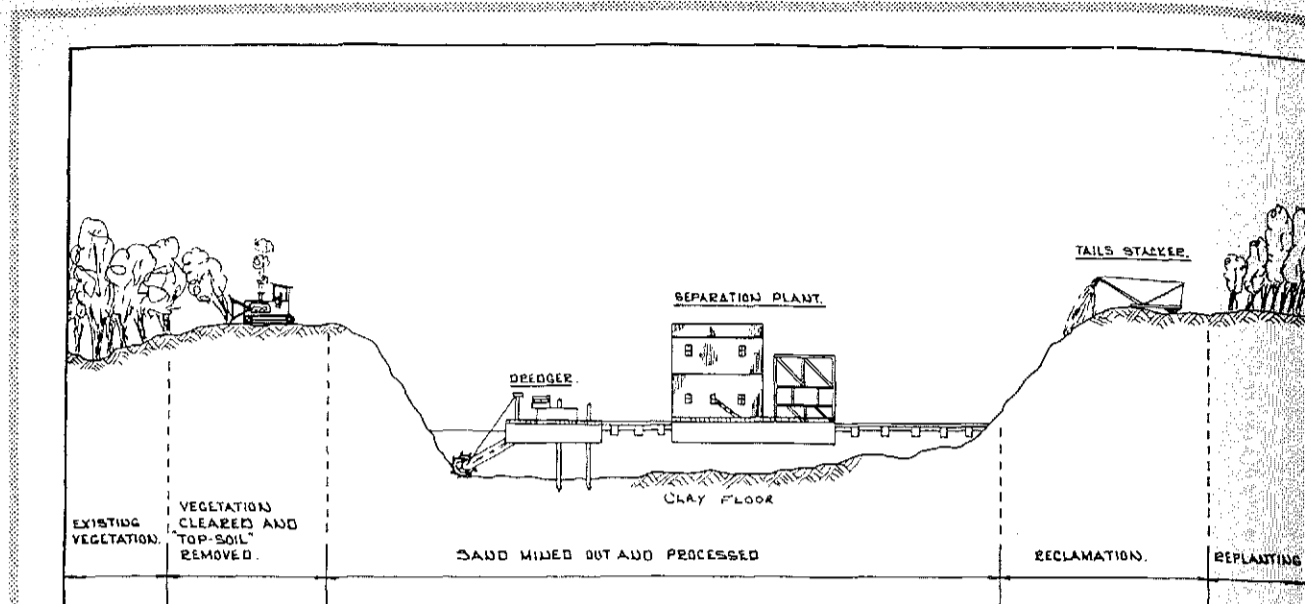


Figure 1: Sketch of RBM dune mining operations: A typical section through a pond

which are attracting increasing numbers of wild animals and birds, and it is difficult to tell the difference between these new areas and the adjacent untouched forest.

When planting commercial plantations, no topsoil is used as the indigenous seedlings it contains compete too vigorously with the commercial seedlings, stunting their growth. Instead, a high concentration of windbreaks are erected and nursery-raised seedlings are planted in-between. After a year, when the seedlings are 1m tall, the windbreaks are removed and the forests are able to mature without further protection.

Complex Issue

The announcement that RBM intended to mine a section of the dunes north of St Lucia evoked an unprecedented response from the South African public. In the ensuing publicity, many of the views expressed were based on incorrect assumptions. RBM accepts much of the blame for this for not responding adequately to people's concerns, and intends setting the record straight by adequate and immediate response to any issues that are of public concern in the future. The following points present the essential facts relating to this sensitive and complex issue.

Many people believe that RBM wants to mine the whole of the eastern shores,

including the St Lucia nature reserve, the wetlands and the beach. In fact, the area to be mined is only 1 200 ha in extent which is equal to 4% of the total area covered by the St Lucia system and 0,4% of the greater St Lucia conservation area recently announced by Minister Kotze. It does not impinge on the reserve, any wetlands or the beach. It is an average distance of 6km from St Lucia lake, and 0,8km at its closes point. It is 10km from St Lucia village, 3,5km south of Cape Vidal and, on the seaward side, never comes closer than 0,4km from the high water mark.

The area at present, far from being pristine, consists mainly of commercial pine forests (56%), 23% is secondary grassland and the remaining 21% consists of young indigenous scrub forest which was grassland in 1937. The climax forest was removed prior to 1937 by extensive grazing by cattle, burning and clearing for agriculture, and human habitation.

There is also concern that the St Lucia estuary and the surrounding wetlands will be damaged by the mining operation. In fact, no water is to be drawn from the St Lucia area. It will be drawn directly from the Umfolozi river at a point where the water would otherwise flow out to sea. The water will be pumped directly to the mine or to a reservoir to be created 1km from the river in an existing clearing in the Dukuduku forest. The reservoir will cover less than

The 1 200 ha area to be mined at St Lucia is equal to only 4% of the total conservation area

1% of the forest which has been extensively damaged by squatters who have been resident there for decades.

The full effect of sourcing and supplying water to the mine and the resulting seepage from the mine to the surrounding areas could in fact benefit the wetlands and the lake. It has been acknowledged that the wetlands have already been degraded by the water-absorbing pine forests lowering the water table in the area; additional fresh water from the mine could help restore the water table. It is also well known that the lake is often under ecological stress due to high salinity levels during dry periods. The fresh water seepage from the mine would be small because the dredge pond occupies only 12ha at any one time and the total area mined in a single area is 75ha. But added to the annual rainfall, it would probably help the salinity problem.

Another area which is being examined in greater depth is the method of transporting ore from the mine to the smelter. RBM acknowledges that the frequent usage of heavy duty haulage trucks would cause a nuisance to residents and tourists, and is investigating alternative methods such as the use of a high pressure pumping system combined with existing rail transport to overcome this problem.

It has been said that dune mining will cause slumping of the seaward dunes. Dune slumping is a natural phenomenon which occurs between Mtunzini and Richards Bay and along other parts of Zululand coast where there is no dune mining. RBM concedes that dune mining can aggravate slumping in geotechnically unstable areas. However, studies have shown that the coastal dunes in St Lucia are more stable than those at Richards Bay and less likely to slump. In addition, the geological structure reveals an absence of the clay layer known to be responsible for slumping in the Richards Bay area.

A great deal has been written about whether the mining will adversely affect tourism in the area. It has been suggested that the development of tourism at St Lucia would be a reasonable financial alternative to mining. Even if the revenue St Lucia currently earns from tourism were to double, it would still be

insignificant when compared with the projected earnings of the mining operation.

There is no reason why tourism should not continue to flourish at St Lucia along with the mining operation. The mine itself only cover 50ha at any one time, it is noiseless and will be almost hidden from view from both the lake and the beach. In time (17 years) the mine will disappear, South Africa will have reaped considerable benefits from the project and St Lucia will continue to attract tourists from all over the world.

Economic Benefits

True conservationists recognise that preservation of the environment cannot be viewed in isolation and that it depends to a large extent on the wealth created by the industry.

South Africa's population is expected to increase from 35,9m in 1988 to 45,1m by the turn of the century. Respected economist Clem Sunter (in his recent book *South African Environments into the 21st Century* which is co-authored by two eminent ecologists) maintains that 'without a 20-year period of sustained economic development, there is next to no chance of reducing the rate at which the population is set to grow and ... environmental health will worsen as numbers take their toll. Any action which impedes economic growth will, therefore, be highly detrimental to South Africa's future conservation prospects.'

St Lucia is surrounded by impoverished Zulus. Already hundreds of dispossessed Zulus have moved into the protected Dukuduku forest on the borders of St Lucia where they have cleared vegetation to build shelters and burned trees to plant crops. Assuming that the black population growth rate of 2,72% per year is maintained, the black population will double within 25 years. Conservation is a low priority in the face of hunger and unemployment.

If education is a key factor in reducing population growth and the ensuing pollution of poverty, then RBM has a key role to play, aside from the much-needed provision of employment. The company's ongoing social responsibility programmes have already had a major

There is no reason why tourism should not continue to flourish at St Lucia along with mining

Conservationists recognise that preservation of the environment depends largely on economic growth



Plate 1: Spot the difference! Acia Karoo forest rehabilitated 12 years after mining operation on the left compared with untouched forest on the right

Once the mining is completed, St Lucia will be restored for future generations in a better condition than at present

impact on local education through bursaries, the construction of a technical college in Esikhawini, the sponsorship of a computerised learning facility at the University of Zululand for the use of the greater Empangeni community, and the 'adoption' of seven schools and two creches in the area where facilities have been upgraded and additional teachers trained and sponsored. RBM has also established a small business advice centre in Empangeni and sponsors numerous conservation and rural development programmes.

From an economic point of view the mine will generate substantial revenue for South Africa in the form of government taxes, foreign exchange and the stimulation of economic growth. These benefits should not be underestimated, especially in view of the reasonable assumption that any action which impedes economic growth must be highly detrimental to South Africa's future prospects.

Conservationists ask whether the expected economic benefits would be worth sacrificing St Lucia. St Lucia will not be 'sacrificed' if mining proceeds. Mining will certainly have an impact on a

portion of the Eastern shores in the short term, although these effects are being thoroughly investigated as part of the EIA; but St Lucia will not be irretrievably lost to South Africa. When the mining is completed most of the area will be well on its way to re-establishing itself. In time the flora and fauna will return to the area but, in the meantime, South Africa will have reaped the manifold benefits of mining at a critical stage in its development and, in the long term, St Lucia will be restored for future generations in a better condition than it is at present.

What is needed is a balanced approach. We at RBM are conscious of the enormous responsibility which would be placed in our hands and are fully aware of the environmental sensitivity of the area. Once the EIA is completed, we would welcome the opportunity of working with conservation bodies, the government and the KwaZulu authorities in an environmentally and economically responsible manner with the shared goal of releasing the wealth which St Lucia has to offer and, at the same time, ensuring its continued existence as one of South Africa's foremost natural areas. **IPVA**

Case Study 2

THE CASE AGAINST DUNE MINING

Dr Anthony Forbes
Department of Biology
University of Natal

The case for dune mining on the Eastern Shores area of the St Lucia system can be summarised very easily: financial benefits estimated at between R2,5 and R5bn, depending on whose estimates you believe, will accrue to the area. In either case the potential for national and regional prosperity is obviously significant.

However, it is axiomatic that, environmentally speaking, there is no such thing as a 'free lunch'. This article attempts to outline *some* of the likely costs to be met in generating such large sums of money. 'Some' is stressed because, unlike the anticipated financial benefits, which can apparently be calculated with some degree of certainty, among the most likely results of environmental impact are that something will happen that was not anticipated, and whatever impact was quantified will be under-estimated.

The draft edition of 'An environmental appraisal of the effects of dredge mining on the Kingsa/Tojan lease region of the eastern shores of Lake St Lucia' was produced for Richards Bay Minerals (RBM) in September 1989 by a trio of ecological consultants. The end result was a document of some two hundred pages to which was added the minutes of various meetings involving local interest groups and decision-making bodies.

I refer to this document extensively, as it represents a substantial collation of existing information, and reactions and concerns to the dredging proposal.

Although not confidential, it appears to have been produced in limited numbers which probably restrict circulation, and I suspect that in any event, few people would be prepared to wade through the

entire tome. The major features are summarised below, since readers might not be familiar with the area. These details are then combined with my own impressions drawn from some fifteen years experience of research at St Lucia.

Contentious Issues

The proposed area of activity as indicated by RBM consists of vegetated sand dunes 150m high in places, sloping westwards to an undulating landscape and then to swampy lowlands adjacent to the lake. The vegetation has been modified by man in the past, particularly through creation of grassland by burning and forest clearing. It now consists of a mosaic of dune forest, scrub, grassland and wetland areas, to which has been added about 3 000 ha of pine forest planted in parts of the grassland areas.

The mining operation involves floating a dredger 65m long and 15,5m wide on a pond 400-600m long, 200m wide and some 5m deep. This procedure will require 30 to 50 000m³ of water per day. The dredger is connected by a 200m pipeline to a concentrating plant 35m wide by 80m long. After extraction of the minerals the sand residue is pumped to the back of the pond. An area of about 300m is kept cleared ahead of the dredger, making removal of all vegetation necessary. Topsoil must also be collected, and this is deposited on the tailings at the rear of the pond for revegetation.

The overall area of the leases has examples of all vegetation types found in this part of the eastern shores, including pine forest. The exact proportion of each

On the one hand, there is obvious potential for national and regional prosperity from dune mining

On the other hand, it is likely that any mining operation will have unanticipated, costly impacts

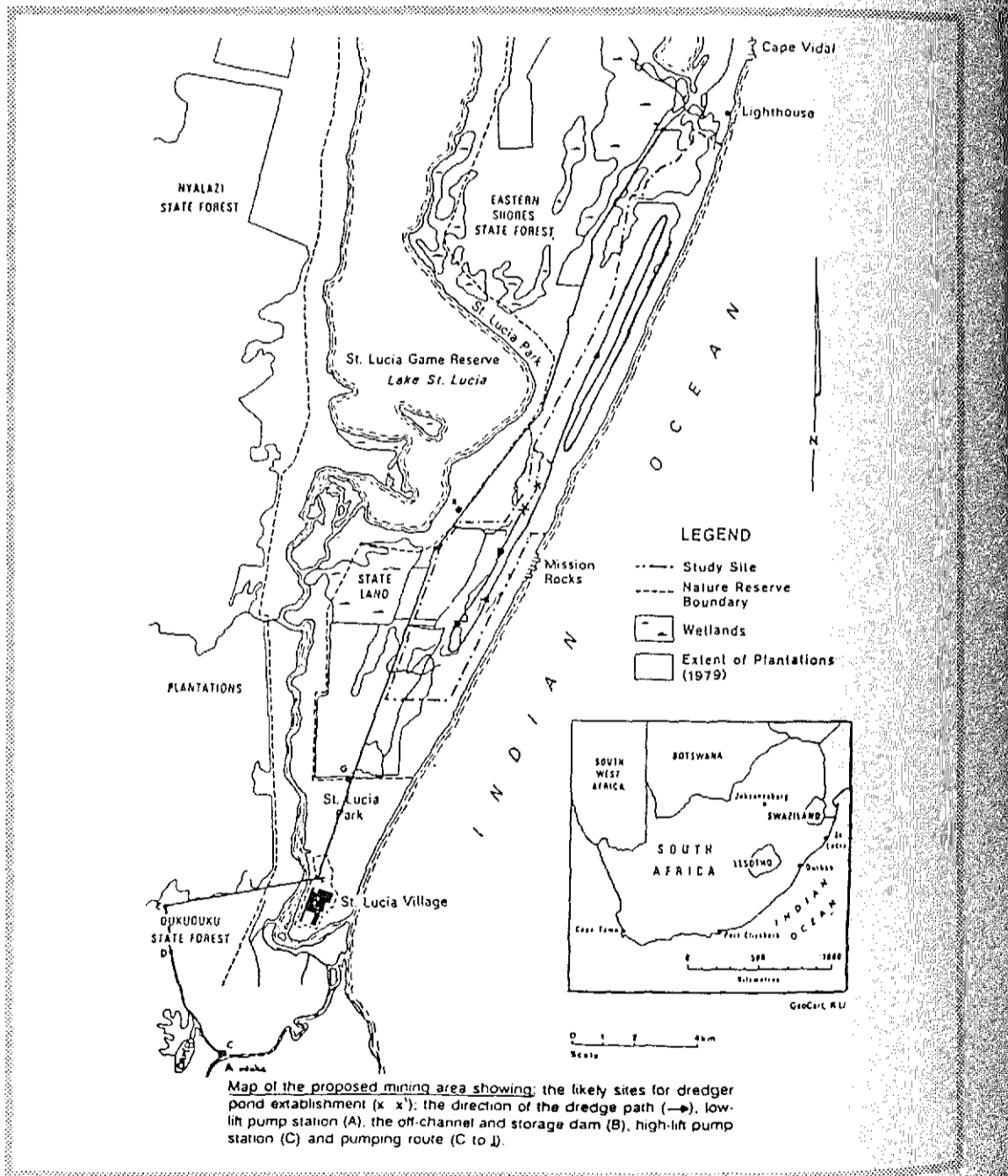
The St Lucia region contains a unique combination of habitats, from high forested dunes to an enormous estuarine system

vegetation type that will be affected depends on the final dredged path, although there can be no doubt that a substantial proportion will be pine forest. Clearly anything that cannot move out of this path will be destroyed, which means that the survival of mobile organisms is ultimately a consequence of their degree of mobility and the possibility of their locating suitable new habitats. The acceptability, not the reality, of these last two points is one of the more contentious environmental issues.

At this point it is useful to view the matter in a broader perspective. The area of the leases is state land controlled jointly by the Directorate of Forestry and

the Natal Parks Board. It is part of a much larger geographical area which falls under a variety of authorities but which, from an environmental point of view, provides a combination of habitats which is unique in South Africa. These include the offshore coral reefs, game fishing areas and turtle nesting beaches of Tongaland, and the forested dunes which are amongst the highest in the world. Inland of the dunes are areas of grassland, scrub and wetland which includes the eastern shores nature reserve.

Overall, this area has immense tourism potential. Further west and north is the lake, the largest estuarine system in



South Africa and probably in Africa. On the western side of the Narrows is the Dukuduku Forest, a remnant of this type of forest in Natal, while to the north the Mkuzi swamps merge into the Mkuzi Game Reserve. Despite substantial human influence, generally adverse, the Eastern Shores area still supports, amongst a variety of other organisms, over 400 vertebrate species and some 40 Red Data Book endangered species of mammals, birds and reptiles.

The argument that mining would have a negligible effect on the whole area has been put forward because of the relatively small area affected and the fairly brief 20 year period over which mining is expected to take place. In addition, the removal of the pine forest is generally agreed to be beneficial. Similarly, the possibility that mining might be an aesthetically and conceptually unacceptable intrusion would be given short shrift in a region which, on a broader scale, already has to contend with a missile range and the biological deserts that are the pine forests. It therefore becomes important to outline the wider implications and their potential human significance.

Environmental Impact

Anything in the dredge path will be destroyed, and whether mobile fauna forced into other areas survive or not is open to question. Dredging takes place round the clock and present intentions are to truck out the heavy metal concentrates to the smelter at Richards Bay. At full capacity there would be 2,7 heavy trucks per hour passing through, 24 hours a day, every day. It is not clear whether this figure represents movements both ways.

Noise would be greatest during the day, with both trucks and bulldozers operating, and would not cease entirely at night, when lights would provide an additional impact. Dust levels from bulldozing and traffic would increase in an area where strong northerly winds are a regular feature. Trucks travelling to and from the area would have to skirt the village en route to the only bridge across the estuary and the only road to Mtubatuba and Richards Bay. Sections of these roads are already heavily used by timber and cane trucks. Increased traffic

brings its own human problems and in areas like the Dukuduku forest will result in roads becoming greater barriers to animal movement from one forest patch to another. Road kills are certain to increase.

A major impact will be associated with the provision of fresh water for the dredging ponds. Virtually the only source of water is the Mfolozi River to the south of St Lucia. It is intended to draw water from this river, which is no longer perennial, and store it in a dam to be constructed in an adjacent area of the Dukuduku forest as shown on the map. At maximum capacity the dam would inundate an area of about 84 ha of an area which is largely grassland - albeit within forest - both of which are threatened habitats.

Water would be extracted and stored during periods of high flow although this is the period of highest sediment content when concentrations of 12 grammes per litre have been recorded, with averages in excess of 1 gramme per litre. The significance of this aspect does not seem to have been fully considered. Water from the dam would have to be piped to the dredge site, with all the implications of the installation process. If the daily requirements are as estimated, this implies an equivalent daily loss probably from seepage, which flows towards either the lake or the sea. The present Richards Bay operation has been associated with extensive slumping of the seaward facing dunes, a process which occurs naturally but has been accelerated by increased seepage through the dunes, an inevitable result of the quantities of water present in the dredge ponds.

The fate of the fine materials introduced into the dredging ponds is still a moot point. Sediment plumes have been found in the sea adjacent to the Richards Bay operations where the water introduced into the ponds is relatively clean. The coast north of St Lucia is characterised by progressively clearer water due to the absence of rivers. An input of sediment into these areas would certainly change the nature of the habitat and adversely affect any coral reefs in the vicinity.

The movement of seepage water towards the lake is claimed to be a potential benefit to wetlands desiccated by the pine forests. The type of vegetation and the

We simply do not know enough about natural vegetation to claim that complete rehabilitation is possible

An even greater problem is recolonisation by animal species which have left habitats disturbed by man

The weighting of adverse effects and potential benefits ultimately depends on perceptions and values

In the St Lucia case, we are faced with decision-making processes on environmental issues that leave much to be desired

significance of a wetland to various animal species depends critically on the volume and seasonality of the water input. The nature and direction of the seepage from the dredge ponds must change with the location of the ponds, making its effects on the wetlands unpredictable.

Rehabilitation

Emphasis has been placed on the apparently successful rehabilitation-revegetation programme at Richards Bay. To talk however, of revegetation and rehabilitation in the same breath is almost certainly naive. Replanting of some grass and trees is one thing but the reconstruction of a climax forest has not to my knowledge been demonstrated anywhere. Studies around Durban in areas of disturbed vegetation but undisturbed substrata show that rehabilitation has not occurred over periods of up to ninety years.

We simply do not know enough about processes in natural vegetation systems to claim that restoration in the strict sense is possible. Any restoration attempts would require a commitment for up to a century in terms of monitoring, experimental and management input if the process is going to be taken seriously. Does this sort of commitment really exist?

Recolonisation by animal species is even more problematic. The more mobile fauna would be able to re-establish themselves as soon as conditions became suitable, whenever that might be. Less mobile types would take longer but in either case, recolonisation depends on the availability of both individuals and undisturbed habitats within a minimum distance.

One could list adverse effects (and potential benefits) virtually *ad nauseam*. Ultimately, the significance of any argument depends on the values of the people involved. The basis of the present problem lies in these different perceptions and values. The vast majority of visitors to St Lucia are fishermen, single-mindedly pursuing their chosen pastime. The infra-structure at St Lucia, from the Parks Board camps and bait shop, to the Super Tube in McKenzie Street and the wares in the local shops, overwhelmingly reflect these particular

interests. If it could be conclusively demonstrated that dune mining would adversely affect the fishing I doubt RBM would get any closer to St Lucia than Mtubatuba.

It might be coincidental, but at a meeting of the ecological consultants and the St Lucia Advisory Committee, first in a list of problems arising in the early stages as envisaged by St Lucia residents was: 'Spill into the environment - the sea water colour from the south is changing and fishing has deteriorated'.

Value Judgements

Whose opinions are to be respected? The squatter in the Dukuduku forest desperate for one of the few short-term jobs? The Transvaal fisherman convinced that the fishing has gone down the drain? The rarer individual who would just like to stroll around the Eastern Shores? The local inhabitant in St Lucia village whose surroundings will never be quite the same? RBM, who appear to be motivated by 'the collapse in the anticipated supply of these minerals from mining developments in Madagascar' and the 'urgent need for RBM to fill the supply from South Africa'? The overseas share-holders?

We are faced with value judgements in an area where the decision-making processes leave much to be desired. Human influences on the greater St Lucia area go back several centuries. The problems have been compounded in recent years by inferior land-use techniques in the catchments and the Mfolozi swamps, by abstraction of water from incoming rivers and even by well-intentioned but misguided attempts at 'improving' the system.

If mining were to occur it is extremely difficult to imagine that the situation would ever revert to square one. If more roads are brought in, if pipelines are laid to bring in large quantities of water, if power lines are brought in, is it even vaguely likely that they would all be removed afterwards? If the dredgers are on the eastern shores and if it is economically viable, is there really anything to prevent them carrying on all the way to Mozambique? One thing is for sure - if mining goes ahead the area will never be the same. **DEVA**

Case Study 3

THE CONVERSION OZONE FRIENDLY PRODUCTS

Ray Rivers

The Aerosol Manufacturers Association

Aerosols have attracted the most attention and emotion in the CFC controversy. Yet chlorofluorocarbons (CFC's) are used by several sectors, as refrigerants in the electronics industry, in the blowing of certain foams, and as propellants in aerosols. Ironically, it is the manufacturers and marketers of aerosols who have made the largest strides to reduce their dependence on CFC's. The transition has been costly, but due to the commitment of the aerosol producers, it has been relatively rapid.

Earlier Lessons

In 1974 in California, two researchers, Rowland and Molina first postulated that CFC's could destroy ozone. By 1978 CFC's were banned from use in all aerosols marketed in the USA, with the important exception of those products of strategic and medical value. This would have been an excellent step towards an improved environment, if it were part of a comprehensive long-term plan to reduce dependence on CFC's in all industrial applications.

This does not appear to have been the case, however. The tonnage of CFC's produced in the USA has actually increased over the last two decades. It is only recently that ecological concerns have come again to the fore. One hopes that we can learn from this experience. If there is a genuine commitment to changing the environment for the better, there must be an appreciation of all contributing factors and continuing pressure until a satisfactory solution has been found. Were this the case in the CFC controversy, we could well have had acceptable alternatives in operation already.

What were the results of environmental action in the USA? In 1973, the total aerosol market in the States was 2,9bn units. This dropped dramatically and it was only in 1988, some fifteen years after the CFC ban that the market exceeded the 1973 figure. The impact of the initial CFC ban is still being felt, however. The National Aerosol Association of America in 1989 carried out market research which revealed that consumers perceive that aerosols still contain CFC's, and many still refuse to use these products.

So the initial banning of CFC's in aerosols is not the end of the road, but almost the beginning, with a long uphill consumer re-education programme ahead.

What of the rest of the world? A few countries, including the Scandinavian states, followed the USA example with a ban of CFC's in aerosols, but the vast majority of countries required more substantial evidence before making a decision on a reduction programme. Accumulation of such data culminated in 1985 when a British scientist found irrefutable proof of the hole in the ozone over the Antarctic. This led to what is known as the Montreal Protocol in 1987, which programmed a reduction in CFC's. Subsequent evidence has indicated that this programme needs considerable acceleration if it is to have any significant impact (see ozone case study).

Aerosol Producers

What of the aerosol producers? For a number of years the majority of household aerosols such as insecticides, furniture polish, oven cleaners etc., have been CFC free. By 1987 it was mainly the personal products, i.e. deodorants,

Researchers discovered as early as 1974 that CFC's in industrial products could destroy ozone

Aerosol producers in South Africa are committed to ending the use of CFC's except where no alternatives exist

The industry has spent millions of rands in converting factories to non-CFC production

The changeover is an investment in an improved environment and in industrial growth in South Africa

anti-perspirants, hairsprays and miscellaneous industrial products including paints, which required conversion. Eight of the largest personal product aerosol producers in the UK pledged to be entirely out of CFC's by the end of 1989.

Members of the South African Aerosol Manufacturers Association are responsible for the production of over 90% of the country's aerosol products. The Association, which includes all the major raw material suppliers to the industry, has pledged to be independent of usage of CFC's by the end of 1990 except for products such as certain medical sprays for which there are no alternatives at present. The commitment of South African producers has been such that the 1990 deadline will be brought forward by around six months.

How big is the aerosol industry?:

- In 1989, total worldwide production, which has been growing steadily for many years, was over 8bn units; the USA accounts for about 40% of the total.
- UK production is around 900m units; total European production is of the order of 2bn units.
- Australia's market, at around 170m units, is very similar to that of South Africa in a number of aspects.
- The South African market in 1988 was 113m units, and as with the majority of aerosol markets, there is already growth over the long-term.

The most recent worldwide figures indicate that the aerosol industry's percentage of CFC's stood at 15%: i.e. 85% of total CFC production is used in areas other than aerosols. The 15% figure is probably out of date because of the quick conversion away from CFC's by aerosol manufacturers.

What about the aerosol industry's contribution to the 'greenhouse effect'?

The main gas responsible for the greenhouse effect is carbon dioxide. However, the CFC gases are many, many times more potent than carbon dioxide. In fact, CFC's are said to be responsible for 12% of the greenhouse effect. Thus the movement of aerosol producers from their dependence on CFC's, not only reduces depletion of the ozone layer, but also has a beneficial effect in reducing

global warming. Furthermore, replacement gases for CFC's which are used as aerosol propellants make an insignificant contribution to the greenhouse effect.

New Investment

What was involved in the aerosol industry's changeover from CFC propellants? Obviously, the first step in purchasing alternatives is to determine that there is a sufficient supply of good quality. This in itself involved tremendous investment in new plants, technology and associated distribution facilities. From the manufacturer and marketers' viewpoints, they have to ensure that consumers will continue to buy a product that is at least equal in quality and performance to what they have been accustomed to.

In itself, this involves a good deal of lengthy research and development to ensure the hardware in the form of the can valve and button. Dermatological and other pharmacological tests have to be evaluated. Consumer trials have to be carried out to ensure acceptability in the market place. Concurrent tests must be conducted to ascertain that the product will have a sufficiently long shelf-life.

Before the final step in production, expensive plant and storage modification may have to be undertaken. All in all, the conversion in South Africa will have cost many millions of rands. It amounts to an investment in an improved environment and in the future of aerosols, a vote of confidence in their advantages of versatility, hygiene, economy and convenience, and an assurance of continued industrial growth in an evolving South Africa.

What of the search for solutions for other CFC applications? Research programmes have been under way for some time into alternatives for CFC's in certain foam blowing, refrigeration and electronics industries. The refrigeration industry is also making strides towards conversion. Certain supermarket stores in South Africa already claim to be 'ozone friendly', and from the progress being made one can expect the next generation of household refrigerators and deep freezers to have completed the conversion. **UPA**

Case Study 4

SOLUTIONS TO PULP POLLUTION

Ben Coetzee and Chris Davies
Sappi Ltd

The Sappi pulp mill at Ngodwana near Nelspruit is designed to operate with one of the lowest, if not the lowest, effluent discharge of any similar mill in the industry. Water consumption is 20 000 l/t product, compared to the typical North American mill which consumes 115 000 l/t product. Corresponding effluent at the Sappi mill is 12 500 l/t product.

This low water consumption is accomplished without recycling bleach plant effluent. Long range plans include bleach plant effluent recycling to eliminate chlorides from the effluent. This progress report describes the design philosophy incorporated in the mill, early startup experience, and plans for the future which will make this mill a landmark example in the industry goal of effluent-free operation. Effluent will then be 7 500 l/t product.

Meeting Demand

The Eastern Transvaal is not a natural choice for locating a major pulp and paper facility. There are no natural forests and water is scarce. However, during the worldwide depression of the 1930s, the South African government undertook an extensive forestation programme in the area near Ngodwana. Large plantations were established consisting of various species of pineal eucalyptus. The location near Ngodwana was chosen because of relatively favourable climatic conditions.

The plantations started reaching maturity in the 1960s. Sappi commissioned a new mill at Ngodwana in 1966, to supply a shortfall of pulp requirements at other Sappi mills. Because of the relatively low

river flow and dependence of downstream agricultural industries on the Ngodwana watershed, the mill was prohibited from disposing any effluent into the receiving stream. This problem was solved by irrigating the effluent (which consisted mostly of evaporator condensate) onto kikuyu grass fields.

By the early 1980s, South Africa was importing a significant proportion of the country's paper requirements. At the same time, per capita consumption of paper was increasing rapidly, corresponding to an expanding industrial base and general economic growth. An increase in pulp and paper production capacity was necessary to meet this increased national demand.

There were several features that made Ngodwana a desirable choice:

- adequate supply of raw materials;
- proximity to major population centres and domestic markets;
- reasonable proximity for export markets;
- available technological base and infrastructure due to existing mill.

However, in spite of all these favourable conditions for siting the expansion at Ngodwana, the location suffered from two major drawbacks. Firstly, the water supply was limited and secondly, no receiving stream or body of water could be used for disposing effluent emanating from the mill.

The decision was made to expand the Ngodwana mill. The unique environmental constraints presented tremendous challenges in the conception and design of the plant.

Sappi's mill at Ngodwana is designed to operate with low water consumption and low effluent discharge

The mill is prohibited from disposing effluent into the low flow Ngodwana river

Unique environmental constraints require innovative designs to reduce water consumption and effluents

The mill disposes effluent in the form of irrigation to a company-owned 480 ha grassland

Environmental Challenge

As necessity is the mother of invention, Sappi's Ngodwana mill was faced with a number of unique environmental constraints which required innovative designs to reduce water consumption and effluent quantities.

Firstly, the Ngodwana river has a small mean flow when compared with most other paper mill rivers. Virtually all rainfall occurs over the summer months with almost no rainfall during the winter. To protect against frequent drought conditions, the project includes a storage dam with a capacity approximately equivalent to one year's water supply.

Secondly, the mill is prohibited by law from disposing any effluent back into local receiving streams. The mill is limited to a maximum effluent which is disposed of as irrigation to an approximately 480 ha area where kikuyu grass is grown and fed to grazing cattle. A herd consisting of approximately 1 000 head of South Devon and Bonsmara cattle flourishes, feeding on the grass irrigated by pulp and paper mill effluent.

Special Features

The Ngodwana mill includes a number of design features which minimise water requirements. Some are innovative while others are simply applications of technologies which have been proven in other mills. Some of the technologies applied to reduce water consumption at the mill are:

- *spill collection*

All pulp mill and recovery area spills are collected in large sumps, pumped to spill collection chests, and gradually pumped back into the liquor cycle via the dilution zone of the blow tank or into liquor storage tanks via a liquor filter. Evaporators have been capacity designed to cope with possible ingress of water or spillages into the cycle.

- *evaporator condensates*

Evaporator condensates are a principal source of process water at Ngodwana, providing much of the makeup water to the causticising area and pulp mill as well as makeup to the large service water cooling systems. To prevent solid carryover, the evaporators are equipped

with extended demisters. Condensates are stripped with air in two systems and the off-gases incinerated. Stripped condensate is stored in large tanks to accommodate process upsets. Excess evaporator condensates are upgraded by micro-filtration and used in the bleach plant as wash water.

- *cooling towers*

There is extensive use of cooling tower systems at Ngodwana. Two large systems provide service water cooling requirements. One for the power house and evaporator, the other for the pulp mill, bleach plant and machines. Makeup to these systems is stripped evaporator condensate.

Other miscellaneous clean cooling waters are collected in a warm water tank and then passed through digester condensers to make a clean source of 75° celsius water which is used at those points in the bleach plant, pulp machine and paper machine areas requiring clean hot water. Hot water is tempered locally to whatever temperature is desired. Excess clean hot and warm water is recycled back to the mill water distribution system via a dedicated cooling tower. Conductivity is monitored to ensure no contamination.

- *pump cooling systems*

Vacuum pump seal water on both pulp machines is filtered, cooled through dedicated cooling towers and recycled back to the vacuum pumps. Water quality is monitored with conductivity meters to ensure that corrosion will be controlled.

- *paper machines*

Although paper machines are not the subject of this paper, considerable water conservation measures are being practiced here also. For instance, most paper machine showers which traditionally use fresh water are piped up to polished water. We are now installing dissolved air flotation for this purpose.

- *bleaching*

One of the key elements contributing to water closure at Ngodwana is the design of the bleach plant. Conventional bleach plants producing market grade pulps generally consist of five or six stages. The first two stages are almost always some version of chlorination followed by caustic extraction.

The oxygen stage is a substantial substitute for the first two stages of conventional bleaching. The use of oxygen at Ngodwana reduces water consumption in two ways. First, there are two less bleaching stages contributing to bleach plant effluent; there is less water introduced from showers, infiltration, wire sprays etc. Secondly, the use of oxygen substantially reduces the chlorine and caustic requirement of conventional bleaching. The water required in the generation and transport of these chemicals is more than cut in half.

In addition, a further reduction in wash water requirements and effluent generated will be achieved by the installation of ultra-filtration equipment on the caustic extraction stage, allowing the recycling of wash water.

The elimination of the chlorination stage vastly reduces the amount of chloride input to the liquor cycle that would occur if the bleach plant effluent were recycled.

• *Built-in options*

The Ngodwana mill includes a number of built-in design features that allow for future technologies. For example, stainless steel in the recovery system and the vapour phase areas in the digester was installed throughout the liquor cycle to allow bleach liquor recycle via counter-current operations. However, chlorides will not be recycled but recovered in the form of hydrochloric acid by external processes for re-use in the chlorine dioxide plant. World-wide patents for this process were filed recently.

Effluent Recycle

Ultimately, future irrigation of effluent must cease. Hence provision has been made for zero bleach effluent discharge, i.e. materials of construction are such that high chloride levels can be tolerated. This will be a phased operation closure.

Pilot work has been carried out which demonstrates that various options are open to us and that treatment is feasible both technically and economically. It is premature to describe the system that will be installed at Ngodwana. The final plant will likely include one or a combination of various technical options. Recovered water from effluent treatment will be of sufficient quality for direct recycle in the pulp and bleach mill.

Faced with a unique set of environmental constraints, some of the most modern technologies and innovative measures have been applied at the Ngodwana mill to minimise water usage. The mill will operate at what is probably the lowest water and effluent usage of any similar integrated mill in the industry.

Long-term plans include complete closure of the bleach plant and paper machines. This is an exciting project, admittedly ambitious, but feasible. The end result could be the first truly effluent free pulp and paper mill in the history of the industry. **IPAA**

Ben Coetzee, former pulp consultant, has since retired from Sappi.

Chris Davies is a mill manager with Sappi.

The mill operates at what is probably the lowest water and effluent usage of any similar mill

Provision has been made in plant design for zero effluent discharge in the future

Environmental Strategies

ENVIRONMENTAL EDUCATION FOR EVERYMAN

Roger Ballantyne and Pieta Tooth-Aston,
Department of Environmental & Geographical Sciences
University of Cape Town

*Industrialists
should
demonstrate
their
commitment
to safe
environmental
practices and
products*

Internationally, the historical role played by industry in contributing to environmental deterioration is well established. It is understood and accepted that economic and political activities, in their intimate relationship with the environment, affect and alter the sensitive physical and social systems within which they operate. In South Africa there are countless examples of the effects of industrial waste and processes on social as well as natural ecology. These indicate a level of negligence and a lack of awareness or responsibility on the part of the South African industrial sector.

Numerous parliamentary acts governing the disposal of industrial waste and the utilisation of resources have been promulgated (see legislative analysis in previous sections). These represent an attempt to curb the alarmingly high rate of industrial pollution and associated environmental despoilation. Legislation is, however, based on the 'best practical means' or conciliatory approach as opposed to the 'polluter pays' approach of most industrialised countries (Koch and Hartford, 1989). This, coupled with an inadequate awareness of relevant laws on the part of industrialists and

unsatisfactory law enforcement has meant that the effect of legislation is minimal in terms of influencing individual attitudes and practice.

Management and labour are insufficiently concerned with possibly negative impacts of their products and processes upon social and physical environments. This is so, even though recent research indicates that top management shows a surprisingly high level of general environmental awareness and concern across a broad spectrum of issues (Preston, 1989). It is essential for future environmental well-being that this concern is translated into appropriate action in the workplace and society.

In the face of growing public concern and an emergent environmental consciousness, industrialists need to demonstrate their commitment to environmentally safe and sensitive practices. Perhaps the most appropriate way to express this, is for industry to embark upon the implementation of environmental education programmes designed to influence the attitudes and behaviour of individuals both at work and in their home environments.

Changing Attitudes

A definition of environmental education proves elusive and varies according to the different emphases favoured by, for example, conservationists and sociologists (Belgrade Charter, 1976; Irwin, 1987; Tbilisi, 1975). However, the definition used in the United States Environmental Education Act of 1977 (Richards, 1985:40) is widely supported and is offered as a general guide:

'Environmental education is an integrated process which deals with man's interrelationships with his natural and man-made surrounding, including the relationship of population growth, pollution, resource allocation and depletion, conservation, technology and urban and rural planning in the total human environment.'

Environmental education is a study of the factors influencing ecosystems, mental and physical health, living and working conditions, decaying cities, and population pressures. Environmental education is intended to promote among citizens the awareness and understanding of the environment, our relationship to it and the concern and responsible action necessary to assure our survival and to improve our quality of life.'

Environmental education can thus be seen as a holistic process aimed at influencing attitudes and behaviour towards both natural and social environments. Programmes should therefore:

- consider the environment in its totality;
- be a continuous lifelong process;
- be interdisciplinary in approach;
- encourage active participation in learners;
- examine major environmental issues;
- stress individual responsibility towards the environment

Recently, government published a White Paper on Environmental Education (1989) which embraces the major emphases as mentioned above. This document is concerned primarily with the introduction of environmental education into the formal school curriculum although it does address the need for government and private sector participation. Unfortunately, the role of industry is confined to that of the

financial sponsorship of formal and non-formal environmental initiatives.

The White Paper (1989) fails to encourage environmental education programmes within industry *per se* and thereby neglects the exciting challenge of education in the workplace. This is a serious oversight in the light of the need to develop an environmentally literate population in South Africa. An industrial setting offers the potential for the achievement of many environmental education aims.

The need for environmental education in industry has recently been highlighted by various companies and industrial unions. Attention has focused largely on health, safety and the conditions of communities living in industrial areas. Some groups have, however, begun to consider links between issues on the shop floor and environmental despoilation. For example, the South African Chemical Workers Union is involved, in association with Natal farmers, in promoting the banning of dangerous herbicides (Koch and Hartford, 1989).

Such initiatives and concerns clearly fall within the ambit of environmental education. While perceptions of environmental issues by management may differ from those of workers, the above case indicates an encouraging common interest in addressing environmental education issues in industry.

Industrial Programmes

One way of ensuring that concern finds practical expression, is for industrialists to design environmental education programmes. The following are examples of goals which could profitably be adopted by industrialists interested in designing such programmes:

- to encourage sound environmental practice in the workplace

In-service training and induction programmes should cover specific areas of the production process, packaging, handling, storage and transportation of goods and waste as well as the effective management of emergencies. Such programmes should form part of the regular in-service training given to

The need for environmental education in industry has been highlighted by companies and unions

The White Paper on Environmental Education (1989) neglects the exciting challenge of education in the workplace

A unique AECI programme illustrates environmental education can be offered in an industrial setting

Employees should be actively involved in learning rather than passively presented with environmental education

employees. The value of such environmental education programmes is that practice within industry will be improved while company commitment to the environment and society at large will be demonstrated.

- *to develop awareness and knowledge of potential socio-cultural and environmental impacts*

Programmes should aim to extend environmental perceptions beyond knowledge of direct causal relationships to encompass broader issues and implications of environmental responsibilities in an industrial society.

- *to engender environmental responsibility among employees*

Individuals should be encouraged to become involved in company policy and decision-making regarding environmental issues as well as participating in local environmental action. Where possible, companies themselves should show their commitment to environmental action by supporting community initiatives and programmes.

- *to promote research into the development of environmentally compatible processes and products*

Instead of being reactionary in response to public pressure, commerce and industry should identify, rectify and pre-empt environmentally hazardous practice.

- *to develop environmental awareness in local communities*

This can be achieved by establishing and sponsoring environmental education centres, recreation facilities and interpretive programmes. Where possible, company property, facilities and resources should be made available for this purpose.

Obviously, these suggestions indicate broad aims and directions. The detailed design and implementation of programmes will necessitate negotiation, consultation and participation involving management, workers, community organisations and environmental education consultants. Such a planning approach will ensure that programmes

are owned and valued by employees and those in the community (Ballantyne and Tooth-Aston, 1989).

AECI Case Study

The environmental education programme currently being planned by AECI Explosives and Chemicals Ltd for Modderfontein illustrates how environmental education can be effected in an industrial setting. The programme is unique in that it is not only to be implemented in the company Conservation Area but in the town and surrounds as well.

Initial discussions between AECI management, ecologists and environmental education consultants has led to the adoption of the following environmental education aims, viz., to:

- demonstrate the harmonious relationship which can exist between environmental and industrial needs;
- promote awareness of the importance of science and technology in environmental management;
- ensure that educational programmes foster an appreciation of the individual's role as a steward of natural and cultural environments;
- ensure that AECI employees have a positive concern for environmental conservation in the workplace;
- foster communication and understanding between school, employee and community groups.

These aims indicate a broad view of the nature of environmental education and encompass the need to develop knowledge, attitudes, values and environmentally responsible behaviour at work and at home. Environmental education programmes will involve students, employees and local inhabitants in formal (structured) and informal (unstructured) experiences.

Participants are to be exposed to the nature of the cultural, social and physical environments and actively involved in learning processes rather than passively presented with environmental information. For example, individuals will be involved in decision-making and problem-solving tasks as well as undertaking some form of environmentally constructive behaviour during education courses.

Preliminary research has identified opportunities and constraints for environmental education in the Modderfontein and Conservation Area. Arising from this, certain suggestions regarding the effective use of the total natural and cultural environment have been proposed. For example, the urban environment could be used to engender an appreciation of the historical development of a townscape, knowledge about the way in which a town functions, a 'sense of place' and an understanding of and commitment to participation in urban decision-making and planning.

In designing experiences to develop such knowledge, attitudes and behaviour, educationalists will be able to use the following elements of the Modderfontein townscape: the Dynamite Company Museum, historical buildings in the area, the AECI explosives factory, the municipal offices and physical and social service facilities. Examples of the many activities which have been suggested are guided interpretive tours of the Company Dynamite Museum where a number of different tours could be developed for school and community groups of different ages and interests using selected themes and stories; guided and self-guided environmental trails of Modderfontein to develop a sense of place and to involve individuals in decision-making tasks.

Target groups such as matric school students, new employees on induction training and local youth movements have been identified. Representatives of these groups are to be consulted during the next planning phase in order to ensure the relevance of environmental education programmes.

Shop-floor Focus

Planning is still at the conceptual stage and there are many issues and logistical obstacles to be confronted. It remains to be seen whether or not aims and challenges will be realised. Thus far, however, the AECI initiative is encouraging and is a good example of a

participatory planning process aimed at achieving industrial environmental education objectives.

Industrial environmental education is in its infancy in South Africa. Where programmes are run, they are often publicity-driven rather than concerned with the deeper issue of addressing industry related environmental problems. In these cases, the focus is upon the public rather than on those within industry. Accordingly, it is not surprising that such efforts may be considered to be self-serving and motivated by a shallow rather than real interest in environmental well-being.

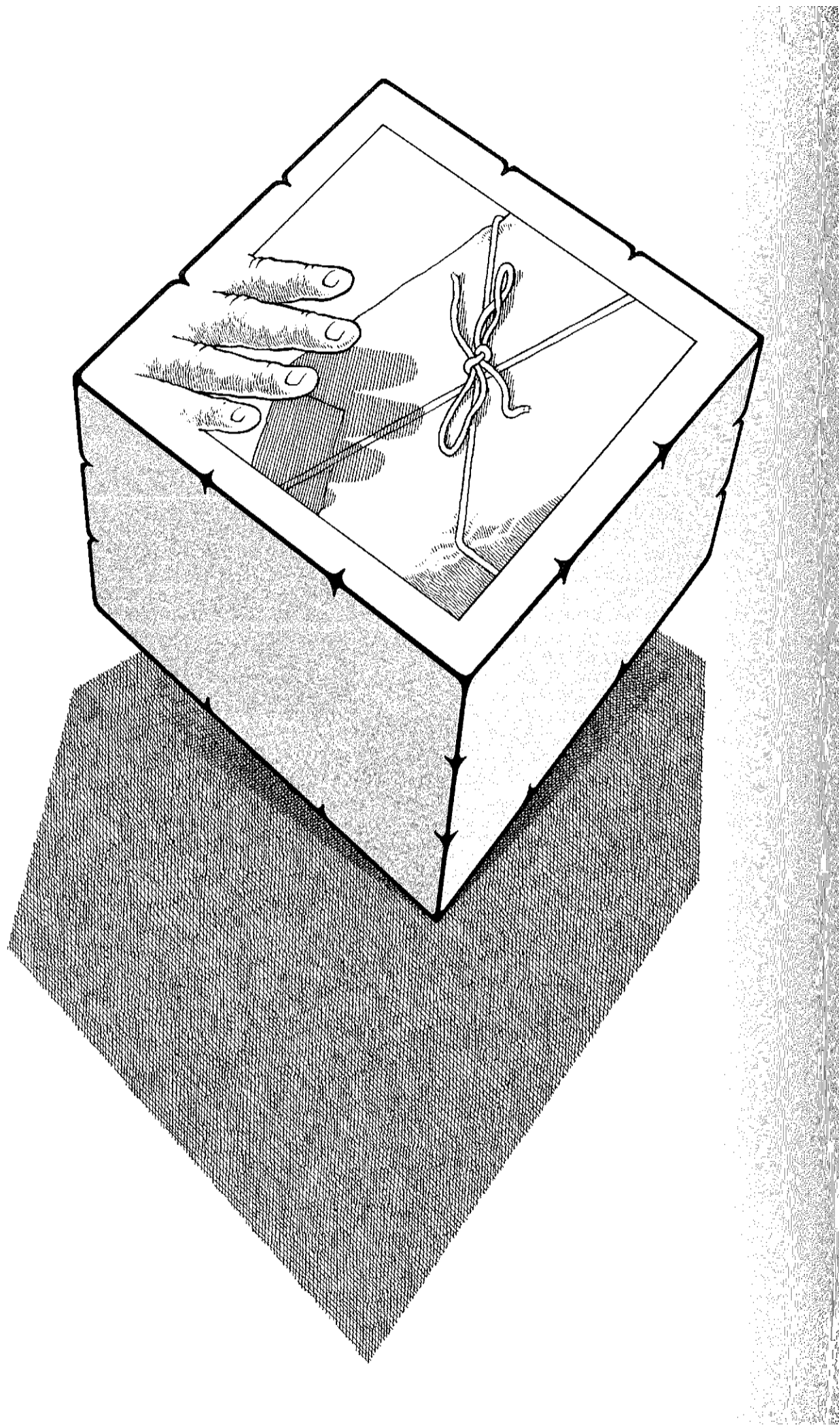
Eloquent company policy and mission statements incorporating a concern for the environment are not enough. The time has come for these intentions to be expressed by management and workers in company decision-making and on the factory floor. **IPQA**

REFERENCES

- Ballantyne RR. *Report on the Modderfontein Conservation Project: Education Plan*. University of Cape Town: Department of Environmental and Geographical Science, 1990.
- Ballantyne RR and PJ Tooth-Aston. In-service environmental teacher training in an apartheid education system, *International Journal of Environmental Education and Information* 8(1): 1989.
- Belgrade Charter, 1975. A Global Framework for Environmental Education. In Council for the Environment Working Documents: Council for the Environment, Midmar Dam, 1984.
- Irwin P. Modern trends in the concept of environmental education. Unpublished paper, 1988.
- Koch E and D Hartford. 'Green', a potential platform for the fight to end apartheid, *Weekly Mail*: 6/10/89.
- Preston GR, RF Fuggle and WR Siegfried. Environmental issues in South Africa: Perceptions of professional ecologists and business leaders, *South African Journal Wildlife Research*, 19(4): 1989.
- Richards DR. An alternative programme for developing environmental literacy in 12 year old South African school children: A study done amongst white senior primary school pupils in Natal, Unpublished M.Ed. Thesis: University of Natal, 1985.
- Tbilisi World Intergovernmental Conference on Environmental Education, 1977. In Council for the Environment Working Documents: Council for the Environment, Midmar Dam, 1984.

Industry must promote research into the development of environmentally compatible processes and products

Eloquent company mission statements on environmental issues are not enough



Part 6

The Demigods Dilemma

WARNING TO CHILDREN

Robert Graves

*Children, if you dare to think
Of the greatness, rareness, muchness,
Fewness of this precious only
Endless world in which you say
You live, you think of things like this:
Blocks of slate enclosing dappled
Red and green, enclosing tawny
Yellow nets, enclosing white
And black acres of dominoes,
Where a neat brown paper parcel
Tempts you to untie the string.
In the parcel a small island,
On the island a large tree,
On the tree a husky fruit.
Strip the husk and pare the rind off:
In the kernel you will see
Block of slate enclosed by dappled
Red and green, enclosed by tawny
Yellow nets, enclosed by white
And black acres of dominoes,
Where the same brown paper parcel-
Children, leave the string untied !
For who dares undo the parcel
Finds himself at once inside it,
On the island, in the fruit
Blocks of slate above his head,
Finds himself enclosed by dappled
Green and red, enclosed by yellow
Tawny nets, enclosed by black
And white acres of dominoes,
With the same brown paper parcel
Still untied upon his knee.
And, if he then should dare to think
Of the fewness, muchness, rareness,
Greatness of this endless only
Precious world in which he says
He lives - he then unties the string.*

Man and the Environment

DEVELOPMENT FOR PEOPLE AND THE PLANET

Bruce Corbett

Development Bank of Southern Africa

In developing countries, long-term growth and sustained development are directly linked to the wise use of the natural environment. Whereas development and environmental conservation were once seen as mutually exclusive, there is now recognition that growth and development, the alleviation of poverty and environmental conservation, are mutually consistent objectives. The human community must live within its ecological means, and development actions must improve man's relationship with essential natural systems.

Southern Africa is characterised by unacceptable inequalities in quality of life, economic activity and control of resources between regions and sections of the population. Whole communities have been bypassed in past patterns of economic growth in a region that has the most extensive infrastructure and industry in Africa.

Development programmes in Southern Africa represent interventions to reduce imbalances and to attend to backlogs in infrastructure and services. The political reform process can be expected to put further emphasis on development as those people who have previously not been able to, now have an increasing say in the distribution of opportunities and resources. These demands are being articulated in the context of a developing, rather than a developed, economy. To many wealthier inhabitants of the region, these realities are becoming evident for the first time.

To the majority of Southern Africa's inhabitants their priority is day-to-day survival by acquiring the basic needs for life and immediate improvements in their lot. This is manifested in a short-term

basis for decision-making which is obviously quite justifiable from an individual's point of view. The natural environment often provides the only available resources the poor may have access to.

Environmental Degradation

In the developed regions of Southern Africa, and worldwide, environmental degradation has been caused quite clearly by the adverse external consequences of economic growth. This has created the conventional wisdom amongst some people that development is to be avoided in an attempt to protect the environment. These are surely the views of people who have a high, or at least adequate quality of life and whose basic necessities for survival are readily secured.

In developing regions the contrary may apply. It is the very lack of economic development, defined in its broadest sense, which is the cause of environmental problems. The problems of poverty, population growth and environmental degradation are inter-linked in these societies. The degradation of natural systems can actually contribute to increasing the imbalances between the rich and poor.

The rural areas of the developing world show environmental stress as a result of sustaining more and more people, living in poverty, who increasingly utilise the limited available natural resources. The renewable stock of natural resources becomes depleted, and a spiral of reduced resources with increasing demands lead to often irreversible damage. Environmental degradation in these areas results in deforestation, soil erosion and depletion, desertification,

Political reforms and a new distribution of resources will put pressure on the natural environment

Poverty, population growth and environmental degradation are inter-linked in developing societies

The natural environment in rural areas often provides the only available resources for poor people

Environmental stress in urban areas is evidenced by soil erosion, water pollution, waste problems and air pollution

water scarcity, bush encroachment, overgrazing, declining agricultural production, and many other detrimental side effects.

Environmental problems in developing urban areas, clearly evident in the slums and semi-slums around Southern Africa's cities, are caused by high population growth rates due to urbanisation, a lack of economic opportunities, improper planning and inappropriate provision of services. The high urbanisation rates presently experienced are due to rural poverty, better opportunities in the urban centres and the removal of legal restrictions applied to blacks who wished to move to urban areas in South Africa. Urban environmental degradation is evidenced by erosion, water pollution, waste problems, overcrowding, social stress, air pollution, and others.

Not all environmental problems in developing areas are due to poverty and population growth. Development projects, which were implemented without due regard for the natural environment have also resulted in adverse environmental effects similar to those in the developed world. Furthermore, many environmental problems are not constrained by man-made borders and the negative effects of one region's activities may impinge on adjacent areas. Examples of these spin-offs analysed in this *Indicator SA* report include water and air pollution, toxic wastes and the worldwide greenhouse effect.

The challenge in developing areas is to reduce poverty and population growth by balanced economic development in such a manner that the existing pressures these problems place on natural systems are reduced, and the potentially negative environmental consequences of economic growth mitigated. Economic development must also reconcile the short-term needs of people with the conservation of natural resources so necessary for sustained long-term economic growth and improvements in quality of life.

Flexible Strategies

After decades of experience, international development has moved away from the mere provision of financial resources for

investment projects. This change has occurred as a result of the obvious failures of interventions in many parts of the world, but notably in sub-Saharan Africa. The average African is now worse off than he was a decade ago. A new approach to development is required to achieve sustainable improvements in standards of living.

Evidence collated from those countries or regions which have fared well shows that development strategies which emphasised economic efficiency and flexibility were the most successful.

To achieve improvements in economic efficiency and flexibility, a process of structural economic reform is required along with investments. Significant policy changes are required to achieve balanced, integrated and multi-sectorial programmes. Singular approaches are not appropriate but rather a number of co-ordinated, flexible strategies should be applied. Environmental considerations form an essential element of both investment projects and structural economic reform.

The backlog in economic activity and infrastructure, which has given rise to low living standards, necessitates support for investment projects. A systematic procedure for the handling of investment projects called the project cycle is applied, in one pattern or the other, by development agencies worldwide. The project cycle consists of a number of phases; starting with identification, then preparation, appraisal, negotiation, implementation and finally evaluation. A multidisciplinary approach is required throughout the project cycle to integrate the numerous aspects of a project and to improve project benefits whilst reducing negative spin-offs. The environmental aspects are considered along with financial, economic, institutional, commercial, social and technical issues.

Environmental concerns must be appropriately introduced at all phases of the project cycle. The oversight of not introducing environmental aspects early on in the project cycle may mean that not all the available alternatives have been considered. If project preparation, including design, is already advanced at this stage, fruitless expenditure and effort may have been expended.

Structural Solutions

Attention must be given to the constraints in developing economies which often limit the extent to which investment actions may result in expanded development programmes and sustainable economic growth. The natural environment forms part of the broad issues considered when such assistance is given, with environmental conservation often being the subject of specific investigations.

The dimensions of structural economic reform where the natural environment plays an essential role are:

- *Development Policy*

Investment projects cannot be successful without the existence of good, clear development policies. Inadequate domestic policies by sub-Saharan states have been blamed for economic, social and environmental decline. Policies formulated for states or regions must be based on sound economic and development principles, e.g. the conservation of natural resources for sustainable development and long-term improvements in quality of life.

- *development planning*

Planning activities leading to practical development strategies for regions are essential for achieving favourable results. These should be multi-sectorial, balanced between rural and urban, agricultural, business, industrial and human resource development, to maximise results with the optimal use of scarce resources. The consideration of natural resource potential and a balanced use of the natural environment between the sectors. Increased agricultural production and the development of tourism should be planned within the limits and features of the natural environment.

- *appropriate technologies*

The technologies applied must be appropriate to the developing milieu, particularly those which impact positively on the environment. At the very least, technologies are encouraged which limit negative environmental consequences.

- *institutional development*

Organisations and legal provisions are essential elements in conservation as free markets generally fail to provide

protection to natural environments. Sufficient institutional arrangements and regulatory control are required to correctly apportion responsibility and usage of natural resources. The limits of finance and qualified manpower of developing organisations pose a serious threat to environmental conservation unless they are systematically improved. Also, local communities must be part of the utilisation and conservation of the environment, so that social attitudes, priorities and traditional uses of natural resources are taken into account.

- *financial systems*

The ongoing availability of financial resources is essential for economic development in general and environmental conservation actions in particular. In the utilisation and conservation of natural resources it is essential that both the private and the public sectors play their appropriate roles. Financial systems must be developed to ensure 'the polluter pays' principle, so that the environmental costs caused by an individual are not borne by society as a whole via taxation.

The public sector has the responsibility for only the very essential regulatory functions necessary for the control and provision of bulk infrastructure, to support private sector financial resources which should be generated for the financially viable aspects of natural resource utilisation such as agriculture, fishing and tourism. Care must be taken to ensure that tariffs are appropriate and subsidies are provided only where justified.

The catch-22 dilemma is that economic development and growth seem to pose a threat to the natural environment in developing areas, on the one hand, whereas the very consequences of underdevelopment, poverty and population growth pose great dangers to natural resources on the other.

The developing areas have the opportunity of avoiding the errors of the developed regions by giving attention to the multi-faceted, interrelated aspects of natural environment utilisation and conservation. The opportunity exists; it must, however, be handled in an integrated and responsible manner, taking into account the realities of the Southern African region. **IPAA**

Economic development must reconcile people's short-term needs with the conservation of natural resources

Environmental considerations form an essential element of investment projects and structural economic reform

Man and the Environment

THE GREEN RESEARCH AGENDA

Tim Hart
Environmental Studies Division
National Institute for Personnel Research, HSRC

A sense of global crisis has crystallised around bleak and alarmist scenarios of environmental destruction

The realisation that human activity ranks alongside major physical forces as an instrument of global and regional environmental change is not new. Nor is the idea that human activity is totally unlike natural forces in that it is an expression of human will. More than fifty years ago, the Russian mineralogist, Vladimir Vernadsky argued that whilst human action had become a major geologic force, the essence of this force lay in the realm of human thought (Clark, 1988).

As issues of global environmental change have become more prominent in the research agendas of the 1980s, the instrumental role of human will (values, motives, interests) appears to have attracted less attention than it deserves, partly due to the relative silence of social scientists and humanists. It is as if they have become paralysed in the face of the 'big questions' (Braybrooke and Paquet, 1988:275).

In recent years, the potentially colossal impacts of population growth, energy and technology have increasingly drawn attention to anthropogenic agents of global change (ibid). A sense of crisis has crystallised around bleak and sometimes alarmist scenarios of the reciprocal worldwide effects on human societies (see Ephron, 1988, *The End*).

Mega-problems (most prominently global climatic change, the ozone hole and population pressure on natural resources) have become foci of public opinion and scientific mobilisation. The greening of politics in many parts of the world is compelling evidence of this trend. The emergence of ambitious programmes such as the International

Geosphere Biosphere Programme (IGBP) shows that even tough-minded science funding agencies have been moved by the rhetoric of global environmental and social crisis.

Through programmes such as the IGBP, the scientific investment in global change and related issues is now enormous. The regional IGBP conference held in Cape Town in December 1989 drew no fewer than 350 delegates, and the programme included a formidable spread of some 150 plenary and poster papers.

For a variety of reasons, the natural and physical sciences have come to dominate international research initiatives around the theme of global change. Some social scientists and humanists have been drawn into programmes such as the IGBP and others have sought to mobilise parallel programmes (IFIAS, 1988). The broader social science community has yet to match the energy and sense of purpose mustered by their natural and physical science counterparts (Braybrooke and Paquet, 1988).

The implications of this research imbalance for scientific programmes are potentially profound and worthy of serious attention by both sponsors and scientists. Although cynics might see employment creation to be the covert motive of the emerging environmental research industry, it must be assumed that most participants in global change programmes are involved because they believe that collective scientific effort can stop or at least diminish potential large-scale environmental catastrophes.

If the social sciences and the humanities continue to hover impotently on the

Can collective scientific effort stop or diminish potential large-scale environmental catastrophes?

periphery, the seminal insight of Vernadsky might be overlooked. The critical role of human will in biosphere change might never be adequately explored and understood. If global change programmes do not channel significant energy into understanding how human interests control, distribute and use resources in the environment, they might fail to address and engage those elements of the collective human will that continue to steer global change. In short, they may prove ineffective in averting the crises that first galvanised them to action.

Panic Logic

In the face of predictions of environmental apocalypse, why have the social sciences and the humanities been so reluctant to embrace vigorous international programmes such as the IGBP? The short answer is that social scientists are in many respects uncomfortable in the culture that has nurtured the involvement of natural and physical scientists.

For example, social science differs from natural science in that it does not devote itself as readily and as completely to the verification and refinement of a new paradigm. In the social sciences, qualification, criticism and demolition frequently punctuate the cumulative growth of knowledge that is taken for granted in the natural sciences (Hirschman, 1981).

Hence, it is much more difficult to devise accepted common objectives and to mobilise sustained international and cross-disciplinary effort among social scientists than among natural and physical scientists. This difficulty is compounded in the case of global change programmes because there is still no incontrovertible evidence that a crisis exists (Braybrooke and Paquet, 1988), or that it overshadows other concerns that presently command the attention of social scientists and humanists. Indeed, critical social scientists have expressed concern about the 'panic logic' which is seen to originate in the technical and uncritical manner in which global change issues have been framed (ibid:284).

Against this background, the social sciences have not developed adequate

conceptual tools to deal with long-run, large-scale interactions between the will and actions of people and the environment. With some notable exceptions, such as demography, few social science disciplines have sought to look at human affairs globally and across generations. Further, experience has taught those social scientists bold enough to model transnational economic and social futures to be extremely cautious about mechanistic models for which there is insufficient information, and which take superficial account of the complexities and capriciousness of human will.

According to Hagerstrand (1988:15), the problem that remains unresolved is the interaction between critical acts of human individuality ('narratives') and the ebb and flow of other environmental change processes ('numbers').

New Synergy

It appears that increased social science involvement in global change initiatives will require both acculturation among social scientists, and some shifts in the natural science culture that currently dominates the global change field. The following are ways in which these synergistic processes might develop:

- Crystallisation of a broad social science research agenda. It would be futile to attempt to unite all social science disciplines around a detailed list of global change research priorities. However, there is already evidence of agreement about broad research domains. Among the most prominent of these are population and resource use, technology values and institutions.
- Identification of focal areas for interdisciplinary research. In the short-term, the most promising way to find common ground is in the context of selected cross-cutting research challenges. Clark (1988) has identified global land use change, industrial metabolism, usable knowledge of global change and institutions for management, and the recent SA-IGBP conference showed promising co-operation around the themes of sea-level rise and the agricultural dimensions of climatic variation.

Global change programmes must focus on how human interests use and control environmental resources

Some scientists argue that there is still no incontrovertible evidence that an environmental crisis exists

The social sciences have not developed tools to analyse interactions between the will and actions of people, and their environmental impact

- Mobilisation of funds to support research which attempts to bridge the divide between social and natural science disciplines. There is at present surprisingly little international investment in the development of the cross-over skills and conceptual tools that seem so necessary in environmental research. In a modest way, South Africa is a leader in this field, through the human needs, resources and the environment programme (Hart, 1986).
- The evolution of a trans-scientific view of global change. It may well be the imperative for action that ultimately provides a common objective for social and natural scientists, partly because this will require compromises and judgements that transcend the canons and sacred traditions of research and discourse in the two cultures.

This 'trans-science' may have to be constructed on imperfect but usable information. It may replace models with scenarios and external 'expert' solutions with participatory trans-scientific dialogue in which a variety of actors have a role in proposing changes in human action and behaviour (Buttimer, 1988).

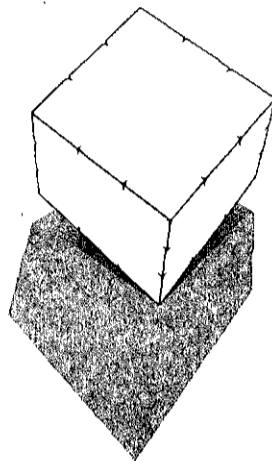
Whilst it may not be judged a scholarly work, the well-known scenario study, *South African Environments into the 21st Century*, published by Huntley et al (1989) captures the spirit of this new approach. It mixes hard science and usable uncertainty in generating plausible visions of regional environmental futures that deal with the socio-political and economic trade-offs, options and conflicts that reside in the realm of human will. **IPQA**

REFERENCES

- Braybrooke D and G Paquet. 'Human Dimensions of Global Change: The Challenge to the Humanities and the Social Sciences', in *Transactions of the Royal Society of Canada, Series V/Voll*:1987.
- Buttimer A. 'Social Implications', in U Svedin and B Heurling (eds), *Swedish Perspectives on Human Response to Global Change*. Stockholm: Swedish Council for Planning and Coordination of Research, 1988.
- Clark W. 'The Human Dimensions of Global Environmental Change', in *Toward an Understanding of Global Change*. Washington: National Academy Press 1988.
- Ephron L. *The End*. Berkeley: Celestial Arts, 1988.
- Hagerstrand T. 'Human Responsibility in the Face of Global Change', in *Swedish Perspectives on Human Response to Global Change*, Swedish Council for Planning and Coordination of Research, Stockholm, 1988.
- Hart T. 'Research at the Man-Environment Interface: The Programme for Human Needs, Resources and the Environment', in *RSA 2000*, Vol8/No6:1986.
- Hirschman A O. *Essays in Trespassing, Economics to Politics and Beyond*. New York: Cambridge University Press, 1981.
- Huntley B, Siegfried R and C Sunter. *South African Environments into the 21st Century*, Human and Rousseau, Tafelberg, 1989.
- International Federation of Institutes for Advanced Study (IFIAS). *The Human Dimensions of Global Change: An International Programme on Human Interactions with the Earth*. Toronto: IFIAS, 1988.
- South African Special Committee for the IGBP. *Abstracts: Conference on Geosphere-Biosphere Change in Southern Africa*. Pretoria: FRD, 1989.
- World Commission on Environment and Development. *Our Common Future*. New York: Oxford University Press, 1987.
- Xiaoyan T and H K Jacobson. *Human Dimensions of Global Environmental Change: Proposals for Research*, Unpublished Report. University of Michigan: Institute for Social Research, 1988.

Conclusion

ROTATING THE CUBE



Brian Huntley, Director
Botanical Research Institute

*Environmentalism, it would seem, has come of age. Gone is most of the emotional rhetoric of the 1960s and 1970s. The 1980s ushered in a changing perception of environmental issues. While acute and catastrophic events such as Bhopal, Chernobyl and Exxon Valdez alerted the world to the dimension of local disasters, there has been a widening realisation that the real threats to our global well-being are much less conspicuous. The insidious, invisible build-up of trace gases such as carbon dioxide, sulphur dioxide and the chlorofluorocarbons poses a more dramatic threat to the future of planet earth than any of the popular high profile **causes celebre** such as the imminent extinction of rhinos, elephants or whales.*

*The consequences of increased atmospheric trace gas concentrations - acid rain, global warming, the depletion of the ozone layer - have demonstrated the extent to which environmental problems have taken on global proportions, for both present and future generations. Only intergovernmental collaborative action, on a scale never previously contemplated, will be sufficient to halt the slow demise of the only habitat in which **Homo sapiens** can live. Yet the 1990s might come to be remembered as the decade of reason - a decade in which the superpowers lead the world not into military conflict but into the war against environmental decay.*

*The many and varied environmental threats that face Southern Africa have been succinctly and lucidly described in the collection of essays in this special report of **Indicator SA**. Some common threads that weave through the contributions are of special significance - for they provide perspectives which are new to the 'green' debate in South Africa and are far removed from the 'bunny hugging' obsessions of the early 1980s. I will address five of these aspects.*

Environmental Holism

Throughout the history of environmentalism, the most active defenders of the faith have been biologists and naturalists. Having identified, described and drawn international attention to a problem, it is something of an irony that ecologists appear to be poorly equipped to solve the problem. Increasingly, solutions to environmental problems lie within the field of competence of chemical engineers, civil engineers, sociologists, economists and politicians. Even the rapidly growing discipline of restoration ecology is dominated by soil chemists, hydrologists and landscape architects - not the botanists and zoologists of old.

Several of the essays in this special report developed a fascinating analogy between environmental management and solving the puzzle of Rubic's cube. For too long, engineers and ecologists have been on the opposite sides of such a cube. And economists, sociologists, politicians, and taxpayers seem to have occupied the other four faces. Unravelling the complexities of achieving economic development, environmental health and quality of life within a balanced programme will require all the skills and holistic perceptions needed in solving Rubic's cube. Interfaces will have to be found between the numerous and often opposing disciplines. Yet we seem to be on the threshold of bridging the gaps.

The CFC saga is a good model. Developed in the 1930s as an odourless, colourless, tasteless and apparently harmless propellant, it was not until the late 1970s that scientists detected a dramatic decline in the ozone concentration in the stratosphere over the Antarctic. Subsequent studies have confirmed a linkage between CFC increase and ozone depletion, and the prospects of increased incidence of skin cancers as a consequence of higher levels of ultra-violet radiation.

While environmentalists lead the campaign against CFC's, the really meaningful action in combating the problem has been taken by politicians, industrialists and chemical engineers. Politicians provided the international diplomatic network necessary for the drawing-up and signing of the Montreal Protocol; industrialists provided the financial resources to undertake the necessary research and development to introduce alternatives to ozone-depleting CFC's; chemical engineers did the research.

This narrative is deliberately simplistic and condensed, but it

demonstrates that the various components of the global Rubic cube can best be solved by the careful integration of skills from a wide diversity of disciplines.

Environmental Trade-offs

Reference has been made by several authors to the well-known truism that there is no such thing as a 'free lunch'. Development cannot be entirely free of some environmental cost. The key determinants of human well-being - economic growth, environmental health and quality of life - cannot be maximised equally and simultaneously. Trade-offs have to be reached.

Electricity provides a classic example in the South African context. While 60% of Africa's electricity is produced by Eskom, over 70% of South Africa's population is excluded from the Eskom network. Yet the provision of safe, cheap electrical energy to all South African households would play a key role in raising the quality of life and economic potential of the entire population. But as several articles in this volume have indicated, the generation of electricity by the giant power stations of the Transvaal highveld introduces over 125m tonnes of gaseous emissions into our atmosphere every year. These gases not only contribute to the global greenhouse effect, but at a regional level have introduced the potent threat of acid rain to an area producing 50% of South Africa's multi-billion rand timber industry, and encompassing 50% of the country's high potential agricultural soils.

Clearly, our national decision-makers will have to consider which of the options to go for - the continuation of a grossly inadequate network of electrification, dramatic increases in the cost of electricity from environmentally clean power stations, or the long-term costs of increased acid rain.

Perhaps the greatest dilemma to be faced by our decision-makers will be the question of adequacy of evidence. Are potential negative impacts to be treated as innocent until proven guilty? Or will our leaders have the courage needed to take hard decisions on soft evidence?

Environmental Literacy

It is no longer adequate to be merely concerned - to be aware, worried or distressed about environmental problems - it is now essential to be informed.

Since the publication of 'South African Environments into the 21st Century' (1989) my co-authors and I have addressed dozens of groups of business leaders, industrialists and politicians of all persuasions. Every occasion has been memorable for the simple reason that today's decision-makers wish to be accurately and objectively appraised of environmental issues.

Not only this, but they express the sincere conviction that eloquent policy statements on the environment are not enough. They see a corporate responsibility to address environmental quality questions within their organisations and to support projects of a wider reach.

Most important, from a business viewpoint, is that an environmentally literate population will have a more rational perception of real versus perceived problems. Contrast, for example, the relative impacts of acid rain over the entire eastern Transvaal highveld with the local, albeit severe, impact of an accidental effluent release; or the destructive erosion and veld deterioration of the catchments of a vastly overcrowded KwaZulu homeland, with the local, acute impact of dune mining. Such comparisons are, of course, ill-advised in the absence of accurate, objective information. But as we approach the twenty-first century and face the need for rational decisions on how to attain the socio-economic 'high-road', such information will become imperative.

Hence funding for problem-orientated research, rather than corporate image building exercises such as the 'save the rhino' campaign - will become a more sensible, if less glamorous, way of investing in environmental projects during the 1990s.

Environmental Technologies

The emergence of interdisciplinary approaches to seeking solutions to environmental problems has introduced the need for many new professional skills. The exponential growth of computer strength has made possible the integration of vast data sets in geographical information systems, which, coupled to the artificial intelligence of expert systems, provides decision aids which greatly facilitate environmental management. Satellite imagery is another modern resource which permits environmental monitoring at a scale and frequency which could not otherwise be undertaken.

Industrialists, under pressure from the public, are now developing environmentally friendly technologies that offer both profit to shareholders and a pollution-free environment to future generations. The promise of an effluent-free pulp and paper plant is made in one of the case structures in this special report. Another contributor suggests that once mining is completed, St. Lucia will be restored for future generations in a better condition than at present.

Wishful thinking, perhaps, but there is ample evidence to suggest that we can expect to see the environmentally damaging, energy sapping technologies of the twentieth century replaced by new, benign technologies in the twenty-first century. Modern technologies, once the greatest foe of many environmentalists, may yet become their most valued ally.

Environmental Players

*Constructive approaches to the solution of South Africa's environmental problems are provided in many of the reviews included in this **Indicator SA** report. Of these, the call for greater powers and autonomy for the Minister of Environment Affairs, and for the creation of an Environmental Protection Agency, are particularly relevant. But in almost every case the assumption appears to have been made that we are on a business-as-usual socio-economic trajectory. Are we not adequately aware that the future is not what it used to be?*

What are the likely scenarios for South Africa in the year 2000? Will we really cross the Rubicon and get onto the 'high road'? Will the civil war unfolding in the heart of Natal plunge us into the wasteland such as that of Angola or Mozambique? Or will we slip back into the securocrat-dominated fortress state of the 1970s and 1980s?

Having postponed the inevitable for several decades, South Africa would seem, at last, to be on the road to meaningful reform. Whatever the long-term outcome of the process, it would be naive in the extreme to expect a trouble-free transition from a Verwoerdian past into a democratic future.

The aspirations of the disadvantaged majority will inevitably lead to increased demands on natural resources, and an understandable impatience with cautious, sustainable utilisation philosophies. The cherished high living standards of the affluent majority will certainly suffer erosion. There can be no doubt that major adjustments will have to be made in our approaches to environmental conservation. The urgency of dealing with the appalling state of the environment in the homelands and squatter camps demands no less priority than the need for massive injections of funds into education, health and housing.

*South African conservationists must now tear themselves away from their indulgence in non-issues such as rhinos and elephants. No longer is it sufficient to claim that these are important flagship species - symbols of greater needs. We are going to have to make environmentalism relevant to the new players in South Africa's future - the disenfranchised majority that will shortly be placing a completely new array of demands on South Africa's resources. Regrettably, few if any of our traditional corps of conservation professionals are adequately prepared to accommodate the vast changes in policy and perception needed to meet the challenges of a new South Africa. **WPA***

INDEX TO DATABASES AND DIAGRAMS

** All data specifically relates to environmental resources and usages in South Africa, unless otherwise stated below*

INTRODUCTION	
Linkages in environmental management	9
PART 1 RUNNING ON EMPTY	
Projected water use	13
Surface water demands	14
Annual average rainfall	15
Surface water loss	15
Change in water use	16
Average population water use	16
Ground water reserves	19
Wetland effect on flood reduction	22
Sediment yield and wetlands	23
Water pollution tests	26
Water degradation by settlement type	28
PART 2 THE AIR WE BREATHE	
Ozone depletion and UV radiation	33
Entering the Ozone	34
Utilisation of CFC's	34
The Montreal Protocol	35
Industrial flume emissions	37
Inversion frequencies over Durban	38
The Natal airshed	39
Regional and topographical winds in Natal	39
Thermal fumigation and pollutants	40
Agro-chemicals and the environment	42
US Clean Air Act	47
Linkages in environmental management	48
PART 3 PLAYING WITH FIRE	
Global warming, 1860-1990	54
The Greenhouse effect	55
Acid rain over Cape Town	58
Primary energy consumption	65
PART 4 RAPE OF THE LAND	
Annual soil deficit	70
Industrial waste by sector	74
PART 5 FROM RESOURCES TO RICHES	
Dune mining operations	86
Proposed St Lucia mining area	90

INDICATOR SA ISSUE FOCUS SERIES

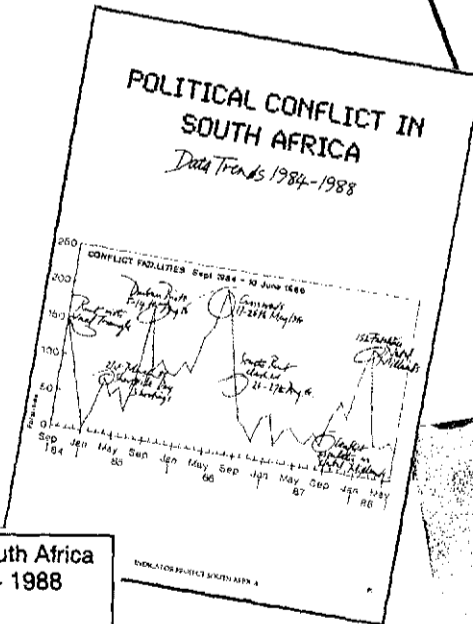
The Classroom Crisis
Black Demands and White Responses
Monica Bot and Lawrence Schlemmer
July 1986
49 pages R15 / US\$10



New Frontiers
The KwaZulu/Natal Debates
(Editors) Karin Roberts
and Graham Howe
September 1987
80 pages R20 / US\$15



Servicing the Nation
Local and Regional Government Reform
(Editors) Mark Bennett,
Andrew Mason and Lawrence Schlemmer
January 1986
72 pages R20 / US\$15



Vir Volk en Vaderland
A Guide to the White Right
Janis Grobbelaar, Simon Bekker
and Robert Evans
August 1989
52 pages R20 / US\$15

Political Conflict in South Africa
Data Trends 1984 - 1988
Mark Bennett and Deborah Quin
December 1988
223 pages R50 / US\$30



Making headway

The Development Bank of Southern Africa

supports development programmes and projects which will improve the quality of life of the people of Southern Africa. Both governmental and non-governmental development agencies in Southern Africa are borrowers of the Bank.

makes provision for a wide range of development projects in the fields of regional, rural & agricultural, urban, business & entrepreneurial, bulk infrastructure and human resource development.

provides a number of other services, including technical assistance loans and grants for, and advice on, development policy and planning, institutional development and financial management, as well as project preparation, research, training and publications on development.

strives to attain its objectives through the promotion of the investment of public and private capital and the use of funds from financial markets and other resources for development.

strives to support all developing areas, regions and states in Southern Africa in its efforts to establish a sustainable development process.



Development Bank of Southern Africa
P O Box 1234, Headway Hill
Halfway House 1685

Tel: (011) 313-3911
Telefax: (011) 313-3086
Telex: 4 25546



Development Bank
of Southern Africa



**BIG BUSINESS
CANNOT SAVE
OUR ENVIRONMENT!**

ONLY PEOPLE CAN

That's why GAME is providing financial support to those in the forefront of environmental management research. So that a dedicated group of concerned individuals can look for answers to the most pressing issues facing mankind today. With our help and that of others, we think that they will succeed.



Indicator Project South Africa.
Contributing to informed debate among South African decision makers of all persuasions.
Will you join them?

In this climate of change and reform, access to facts behind the emotive issues is essential. This is the rationale behind Indicator SA — to bring the South African debate into the open. To provide a forum where all sides can be heard. To provide data analysis, trend diagnosis and policy prognosis.

The result is a quarterly journal divided into five monitors: political, economic, rural & regional, urban and industrial. Indicator SA is available by subscription and from selected bookshops.

Free — by subscription only

As part of our service to subscribers, you will receive at least two major reports on conflict issues in addition to your four Indicator SA editions during your subscription year.

These reports are definitive studies of restricted circulation and are highly prized.

As a subscriber you receive them free!

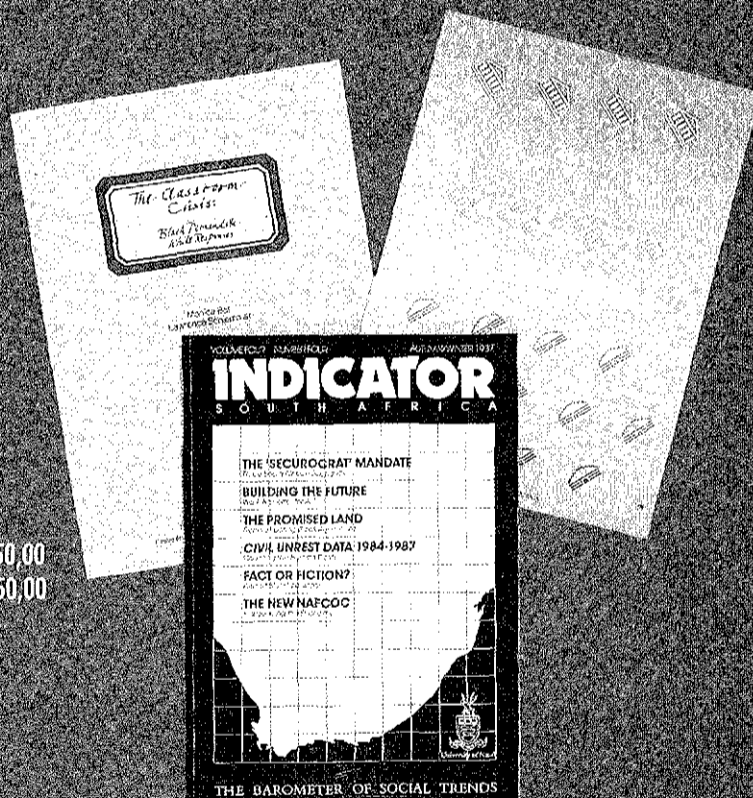
Rates

Individual, institute, practice, other R150,00
Overseas - non-corporate \$150,00

For information on corporate/donor subscription rates and advertising facilities, please contact:
Indicator Project South Africa
Centre for Social & Development Studies
University of Natal
King George V Ave
Durban, 4001
South Africa
or contact the Liaison Officer at (031) 816 2525/2369.

Subscribe now

If you are committed to South Africa, as an individual or in a corporate environment, Indicator SA makes essential reading.





University of Natal

INDICATOR PROJECT SOUTH AFRICA

Centre for Social and Development Studies
University of Natal • King George V Ave • Durban • 4001 • Tel. 816 2525 or 816 2369

This work is licensed under a
Creative Commons
Attribution – NonCommercial - NoDerivs 3.0 Licence.

To view a copy of the licence please see:
<http://creativecommons.org/licenses/by-nc-nd/3.0/>