

# Developing country-specific impact procedures:

## Human health and ecosystem quality as criteria for resource quality and availability

**Alan Brent**

**Chair: Life Cycle Engineering**

**University of Pretoria**

**South Africa**

**Tel: +27 12 420 3929**

**Fax: +27 12 362 5307**

**E-mail: [abrent@eng.up.ac.za](mailto:abrent@eng.up.ac.za)**



# Objectives of the presentation/discussion

- **Sustainability in the South African context**
- **Current Life Cycle Impact Analysis (LCIA) procedures in the South African context**
  - **Impact categories and characterisation**
  - **Normalisation**
  - **Weighting**
- **A proposed framework for a LCIA procedure for South Africa**
- **Proposed regions for focussing LCIA's**
- **Additional work required**

# The South African natural environment

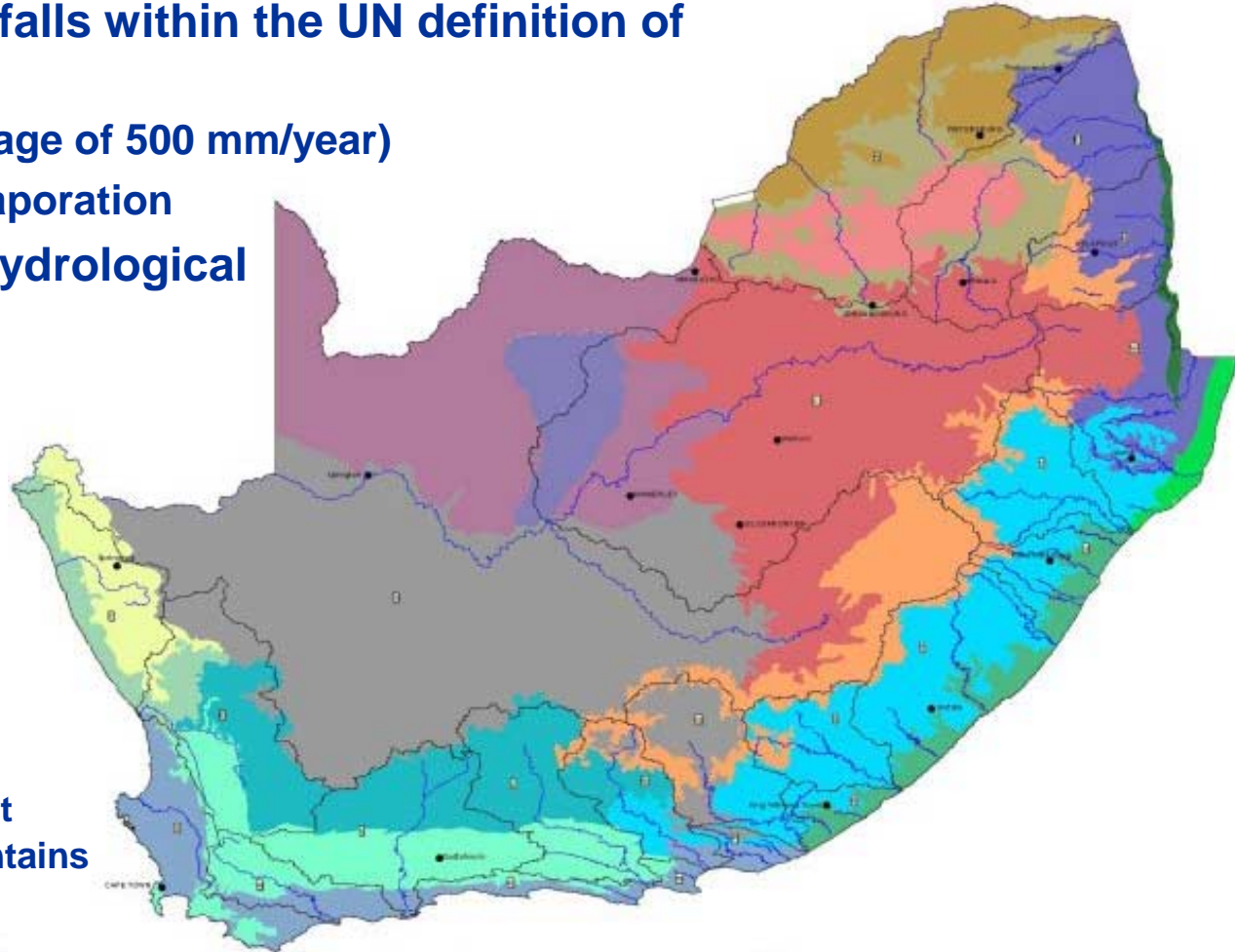
- **Third highest level of biodiversity in the world**
  - 7.5% of the world's vascular plants
    - 18000 species of which over 80% occur no where else in the world
  - 5.8% of the world's mammal species
  - 8% of the world's bird species
  - 4.6% of the world's reptile species
  - 16% of marine fish species
  - 5.5% of the world's recorded insect species
- **Diversity is due to a broad range of climate, geological, soil, and landscape forms**
  - 18 eco-regions
  - 68 vegetation types
- **Less than 10% conserved**
  - Highest concentration of threatened plant groups in the world



# Eco-regions of South Africa

- 91% of the country falls within the UN definition of “affected drylands”
  - Low rainfall (average of 500 mm/year)
  - High potential evaporation
- High variability in hydrological regime

- Highveld region
- Nama karoo region
- Eastern uplands
- Cape folded mountains
- Southern coastal belt
- Bushveld basin
- Southern kalahari desert
- Great escarpment mountains
- 10 other eco-regions





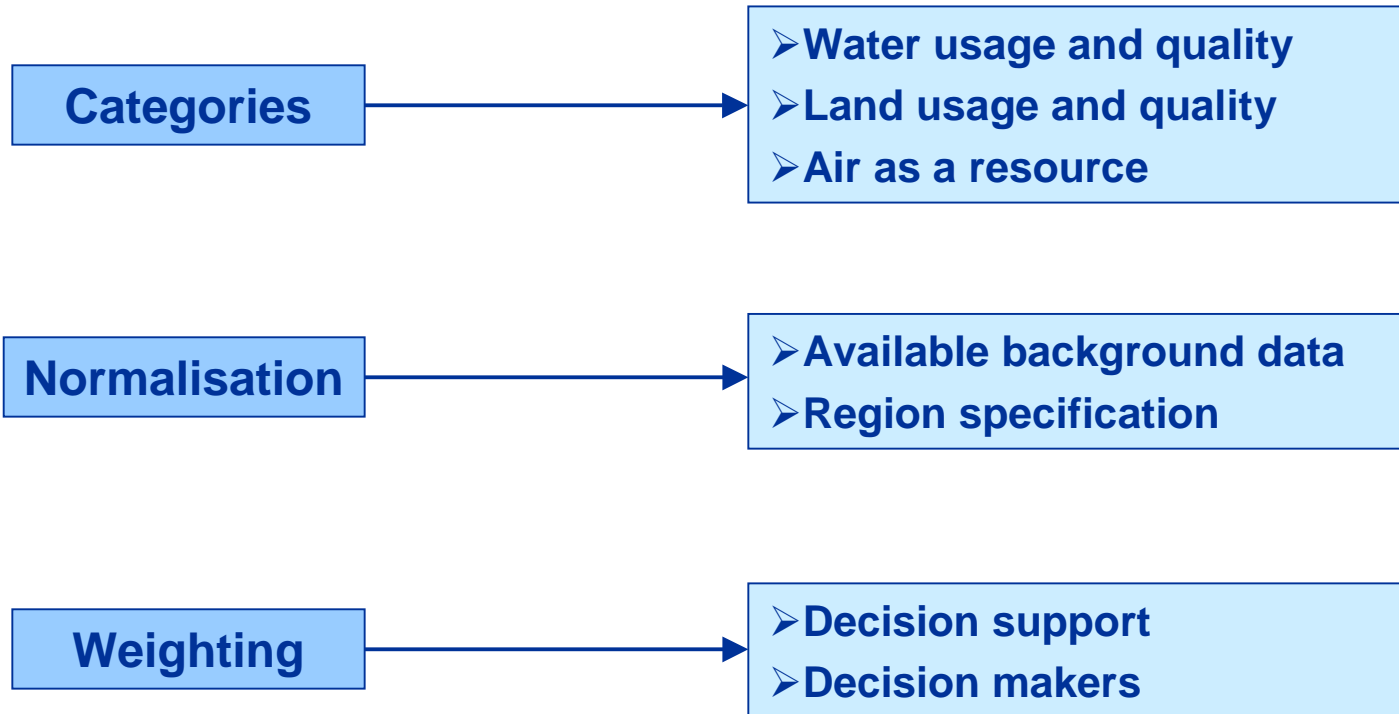
# Associated problems experienced

- **Limited surface and groundwater resources compared to world averages**
  - Lack of important arterial rivers and lakes
- **Water requirements and availability**
  - Demand is set to exceed supply by 2020
  - Pollution of freshwater systems
    - Agricultural runoff
    - Discharge from informal urban settlements
- **Sporadic wet and dry periods**
- **Together with the lack of effective land-use planning and land mismanagement**
  - Loss of habitat and prime agricultural land
  - For example, dramatic increase (35%) in the loss of topsoil

# Related sustainability issues in South Africa

- **86% of land surface area is classified as agriculture**
  - Most is grazing rather than crop cultivation land
  - But, agriculture only contributes 4% of the total GDP
  - Largest agricultural export is maize; second is wool
- **27% of GDP attributable to the manufacturing industry**
  - Largest relating to the metallurgical industry
  - Immense concentration of the world's mineral wealth
    - Chrome (72%), platinum (88%), gold (40%), manganese (83%)
    - Export of raw materials, e.g. iron ore
    - Associated mining activities and impact on land
- **Industrial sector compares with developed countries, but a large proportion of the country and its population is subject to developing country conditions**
  - 50% of households have access to formal energy and water supply, and first world latrine and waste disposal facilities

# Current Life Cycle Impact Analysis (LCIA) procedures in the South African context



# Impact categories and characterisation

## ➤ Water usage and quality

- Quantity used critical for the overall resource
  - Differentiation of type, i.e. pristine vs. treated water
- Additional quality indicators required
  - Toxicity for human consumption and agricultural irrigation
  - Water salination due to mining activities, etc.
  - Acidification; from atmospheric SO<sub>2</sub>, and directly from acid drainage

## ➤ Land usage and quality

- Generalisation of land types for the different eco-regions
  - Quality of land used different for different parts of South Africa
- Midpoint categories must reflect impact on land quality

## ➤ Air as a resource

- South African constitution dictates environmental rights
  - Includes equitable allocation of resources of acceptable quality
  - Comprises water, land and air

# Normalisation

## ➤ Available background data

- **National databases of emissions and resource uses seriously lacking**
  - **Responsibility of three national governmental departments**
    - Department of Environmental Affairs and Tourism
    - Department of Water Affairs and Forestry
    - Department of Minerals and Energy
  - **Control and guidance allocated to regional level**
    - EIAs approved by local government
- **National databases of current state and quality available**
  - **Water measurements in all eco-regions**
    - Metals, organics, flow, etc.
  - **National land cover database**
  - **Air quality measurements at local level**

## ➤ Region specification

- **Eco-regions of South Africa should be taken into account, if possible**



# Weighting

## ➤ Decision support

- **Design and engineering**

- **Single score for a new product**
  - Needs generalised normalisation and weighting (not eco-region specific)
- **Single score for a new process**
  - Weighting needs to be eco-region specific
  - Placement of a new plant in different regions of South Africa

- **Analyses**

- Requires indication of area-specific impacts; but not EIA

## ➤ Decision makers

- **Cultural diversity in South Africa**

- 11 official languages

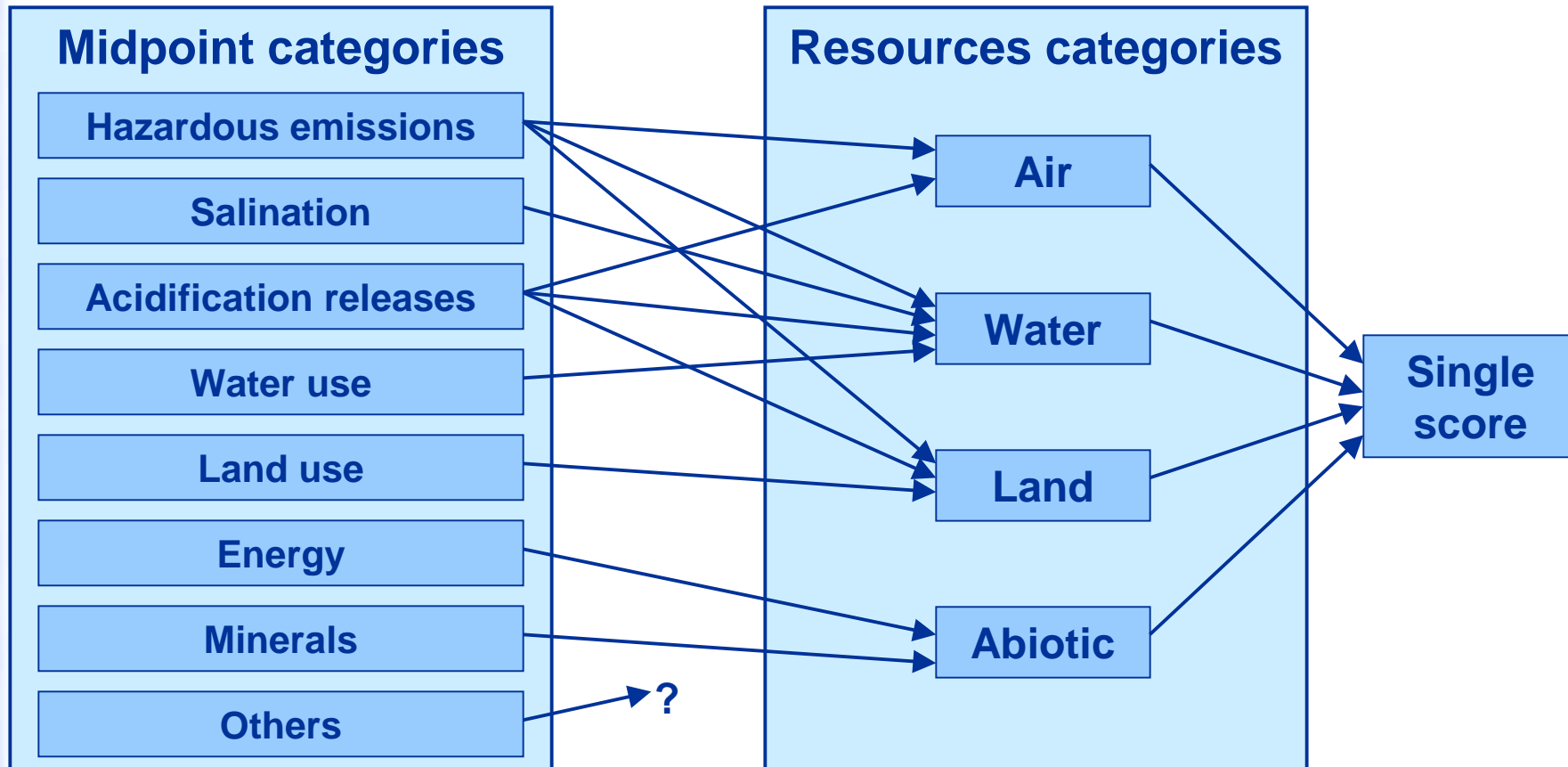
- **Corporate versus government-type decision maker**

- **Significance and value of impacts regarded differently**

- Kind of person and external pressures, e.g. market forces



# Proposed framework for a LCIA procedure in the South African context



# Midpoint categories

## ➤ Units of measurement

- **Equivalences as defined in the current LCIA methodologies**
  - Some in development, e.g. water salination
- **In line with practices in other fields of science**
  - Indicator species for South African aquatic and terrestrial environments

## ➤ Normalisation of the midpoint categories

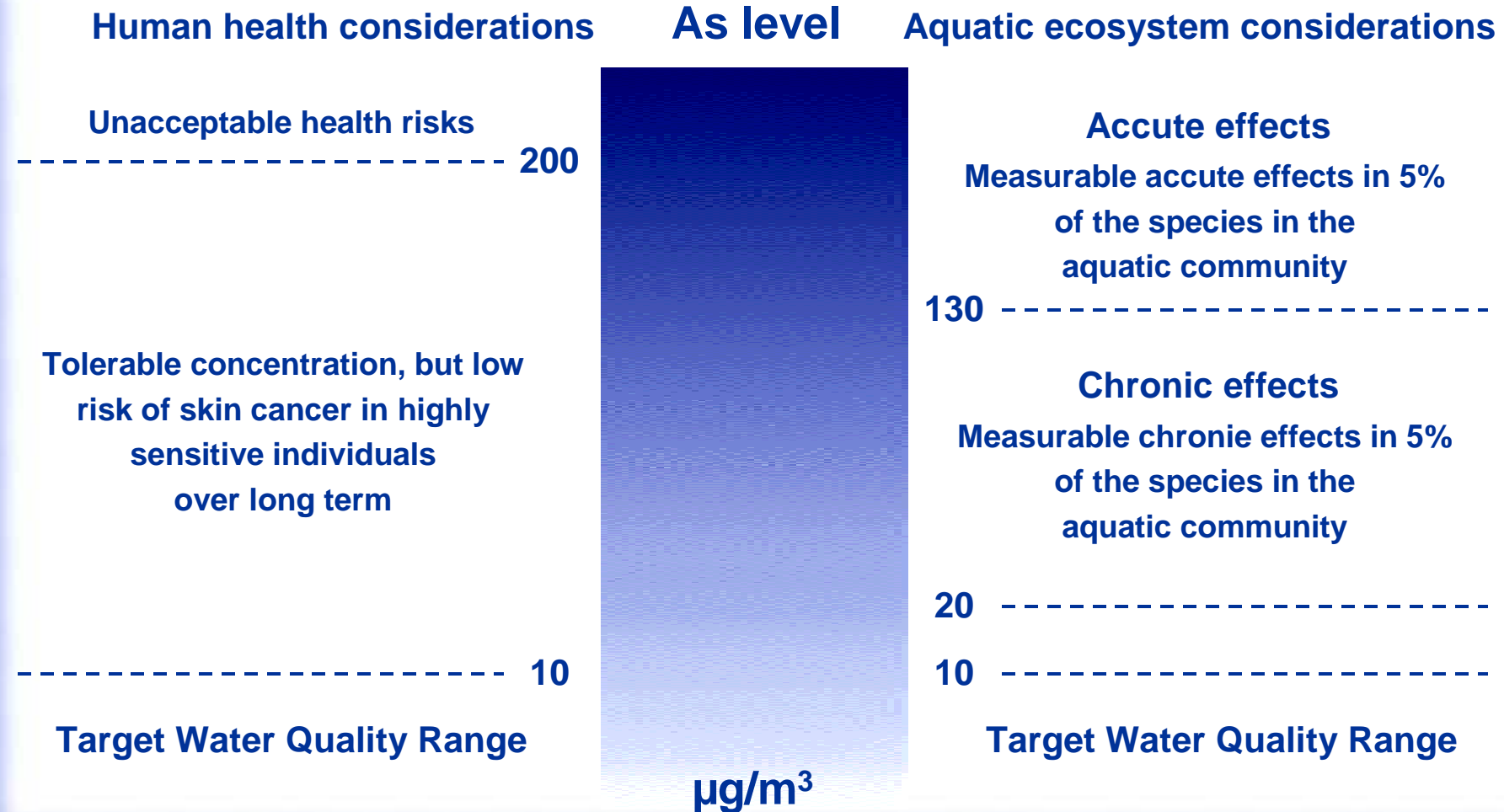
- **Current state data for the different eco-regions**

## ➤ Weighting of midpoint categories

- **Distance-to-target methodology**
- **Determined by the specific resource of impact**
  - Air, water, land, and abiotic
- **Acceptable levels for the impact categories determined by human health and ecosystem quality requirements**
  - Ambient ratio rather than specific LCI ratio

# Example of arsenic level requirements in fresh water

#1



# Example of arsenic level requirements in fresh water

#2

Weighting	Value	Background quality
High	5	200 $\mu\text{g}/\text{m}^3$ : Unacceptable risks to human health and the ecosystem in a region due to arsenic concentrations
	4	130 – 200 $\mu\text{g}/\text{m}^3$ : High risk to human health and measurable acute effects to the aquatic ecosystem
Medium	3	20 – 130 $\mu\text{g}/\text{m}^3$ : Increased risk to human health and measurable chronic effects to the aquatic ecosystem
	2	10 – 20 $\mu\text{g}/\text{m}^3$ : Slight risk to human health and no measurable effects to the aquatic ecosystem
Low	1	0 – 10 $\mu\text{g}/\text{m}^3$ : No effects on human health or ecosystem in a region due to arsenic concentrations

# Resources categories

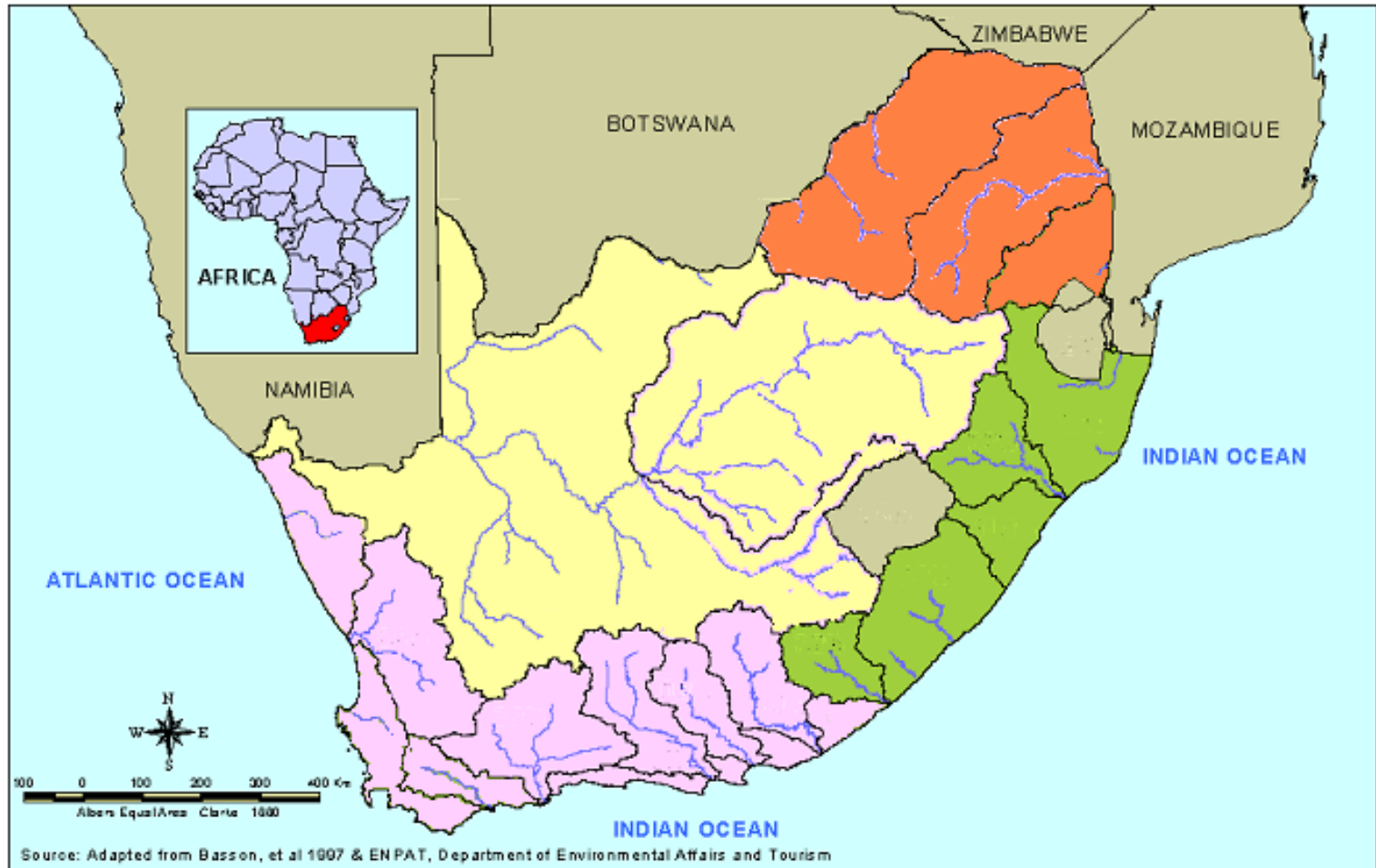
- **Assessed in terms of the sum of all midpoint categories that affect the considered resource only**
  - No specific units of measurements
  - No normalisation
- **Weighting of the resources categories**
  - Multi-criteria procedures a possibility
  - Subjective weighting will be required
    - Costs to improve the quality and availability of the resources
    - Social value of the resources
      - Vague and strongly influenced by opinion of different cultural views
    - Preferences of local government in a specific eco-region
      - Annual costs budgetted to address concerns relating to the different resources
- **These categories serve to focus the midpoint categories**
  - Caution must be taken for double-counting

# Overall calculation of the single score

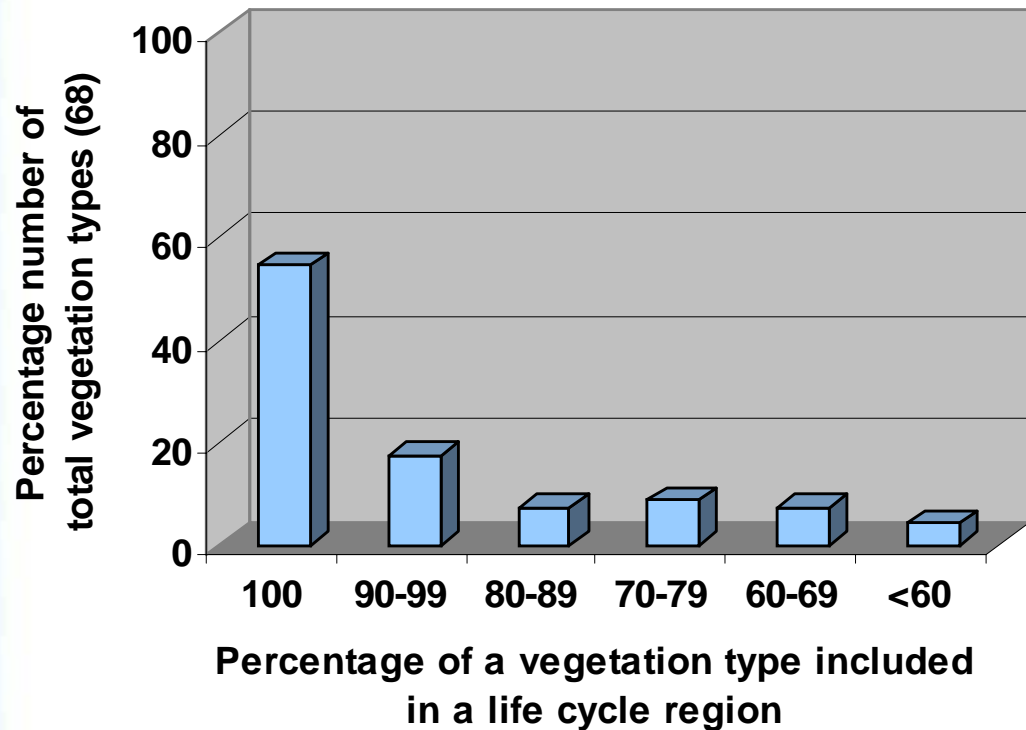
$$I_s = \sum_C \frac{I_C}{N_C} \cdot W_C \cdot W_R$$

- $I_s$  = Impact of life cycle system
- $I_C$  = Life cycle inventory value in a midpoint category
- $N_C$  = Normalisation value of a midpoint category
- $W_C$  = Midpoint category weighting value in a region
- $W_R$  = Resources category weighting value in a region

# Four proposed life cycle regions within South Africa (based on the primary water catchments)



# Representation accuracy of the life cycle regions in terms of the vegetation types of South Africa



Percentage inclusion of a vegetation type in a life cycle region

Cumulative % of total vegetation types

100

54

> 90

72

> 80

79

> 70

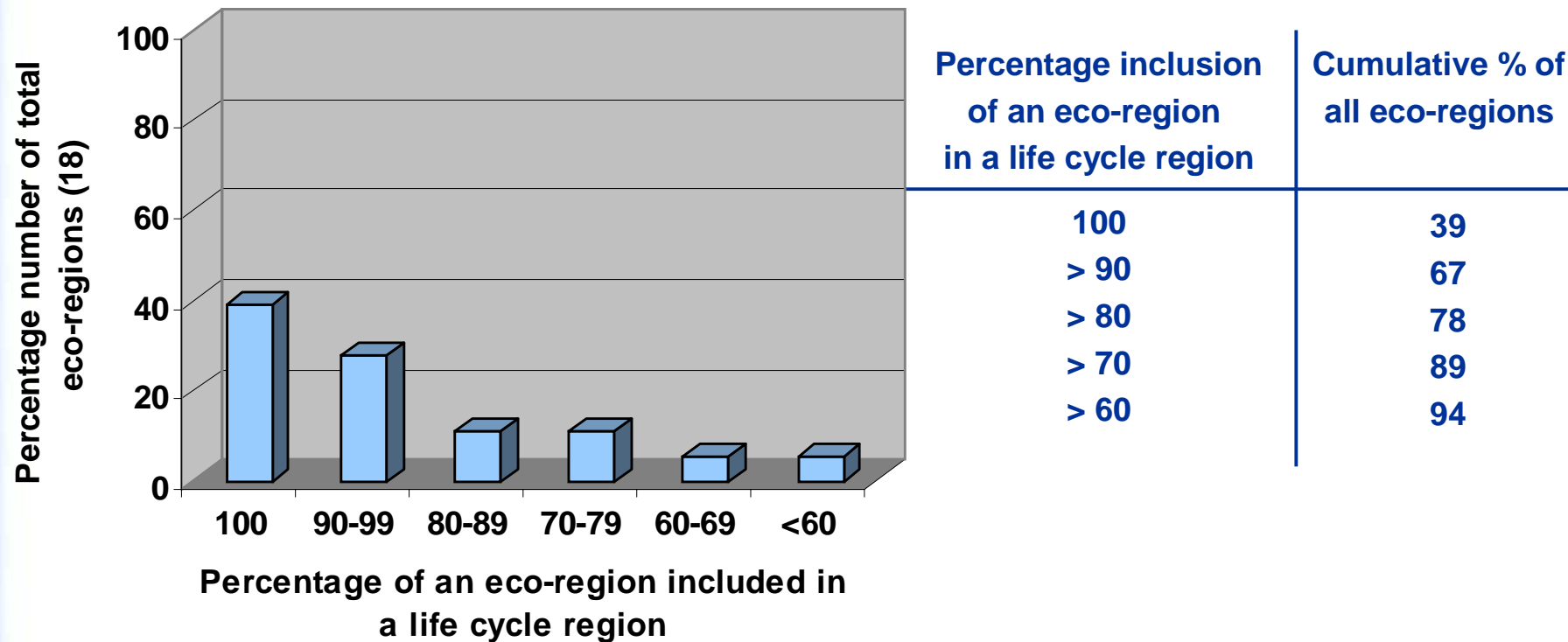
88

> 60

96

**In excess of 90% of the surface area of more than two-thirds of the South African vegetation types are included in the life cycle regions**

# Representation accuracy of the life cycle regions in terms of the eco-regions of South Africa



**In excess of 90% of the surface area of more than two-thirds of the South African eco-regions are included in the life cycle regions**

# Additional work required

- **Extrapolate background databases into LCIA format**
  - Water quality inventories
  - Land cover database
  - Existing air quality data
- **Choose relevant indicators for South Africa**
  - Hazardous emissions
    - Available background data
  - Salination
  - Equivalence factors
- **South African case studies to evaluate procedures**
  - Products that impact all four resources
    - Air, water, land, abiotic