Implications of land use mix on the sustainability of developing urban centres: A case study of Stellenbosch, South Africa

Walter Musakwa and Dr A Van Niekerk

Department of Geography and Environmental Studies,
Stellenbosch University

Structure

i. Introduction
ii. Sustainable land use indicators
iii. Impact of land use mix on sustainability
iv. Study area
v. Methods
vi. Results and discussion: Land use change, land use mix, land use frequency.
vii. Practical implications and conclusions

Introduction

- High rates of urbanisation in developing nations often leads to unsustainable land use practices.
- Sustainable development is a noble concept yet it is difficult to put into practice.
- Data to monitor sustainable land use is often lacking, not in usable format, unreliable, or expensive to collect.
- Earth observation collects data on land use/cover which is periodically collected and provides a synoptic view - perhaps is a solution to monitor sustainable practices?

Decision consequence analysis

- Decision consequence analysis breaks down the uncomplicated nature of sustainable development.
- Basic elements of DCA are an unacceptable current condition and a desired future condition.
- To achieve a transition between these two it is necessary to have an understanding of each condition.
- There is paucity of research that focus on measuring land use mix

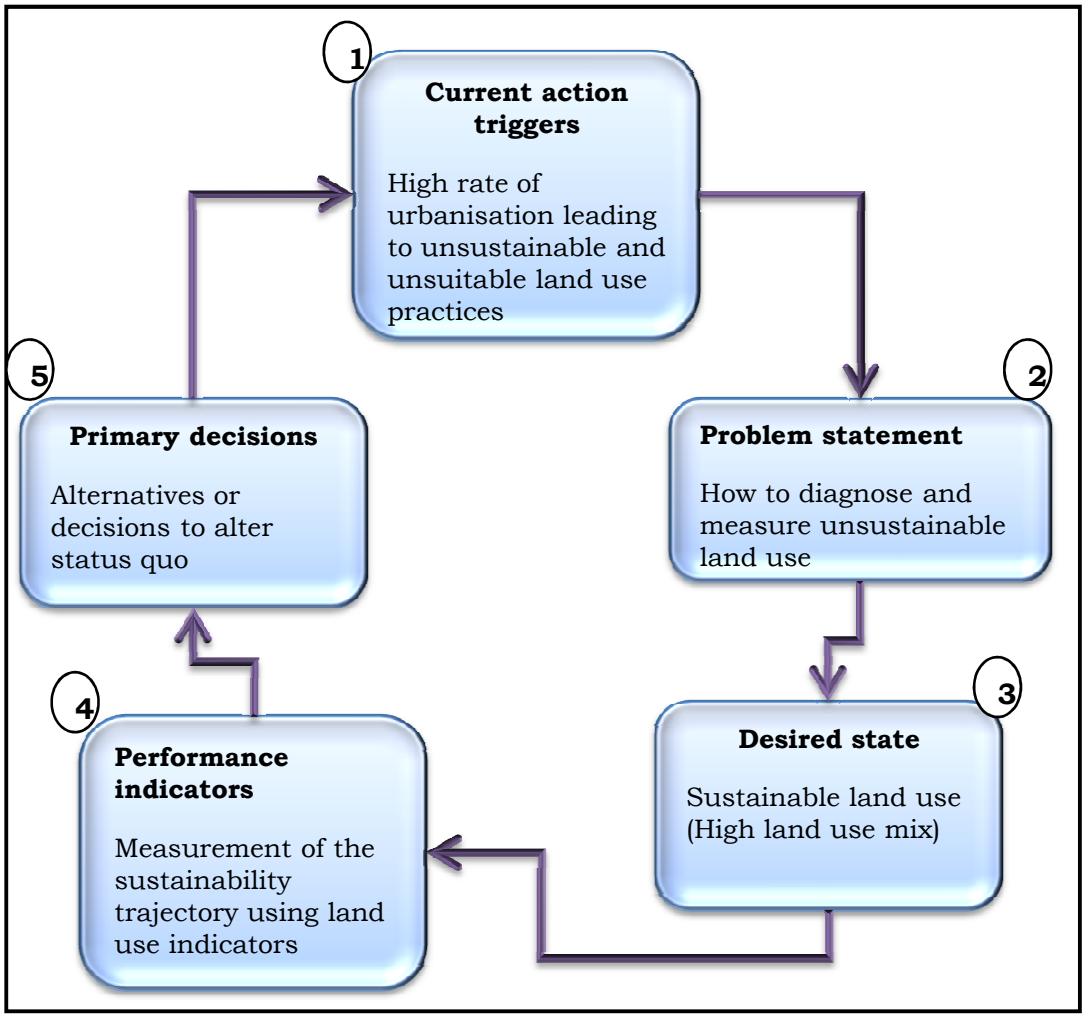


Figure 1: Principles of decision consequence analysis. Adapted from Hall (2010)

Sustainable land use indicators

Indicator	Unit of measurement	Analysis scale	Significance and thresholds
Land use mix index (LUM)	0-1	Neighbourhood	A land use index of 0 denotes low sustainability and 1 highly sustainable.
Land use frequency (LUF)	Frequency	Neighbourhood	A high number of complimentary land uses per neighbourhood are desirable for sustainability unlike low mixing intensity.
Land use change (LUC)	Percentage	City or town level	Land use change impacts all the other indicators. A change from natural ecosystems to urban use is generally unsustainable.

LUM= {−Σ[(□)(□□□)]} / □ where □ is the proportion of each land use class per neighbourhood; □ is the natural logarithm; and □ is the number of land use classes per neighbourhood

Impact of land use mix on sustainability

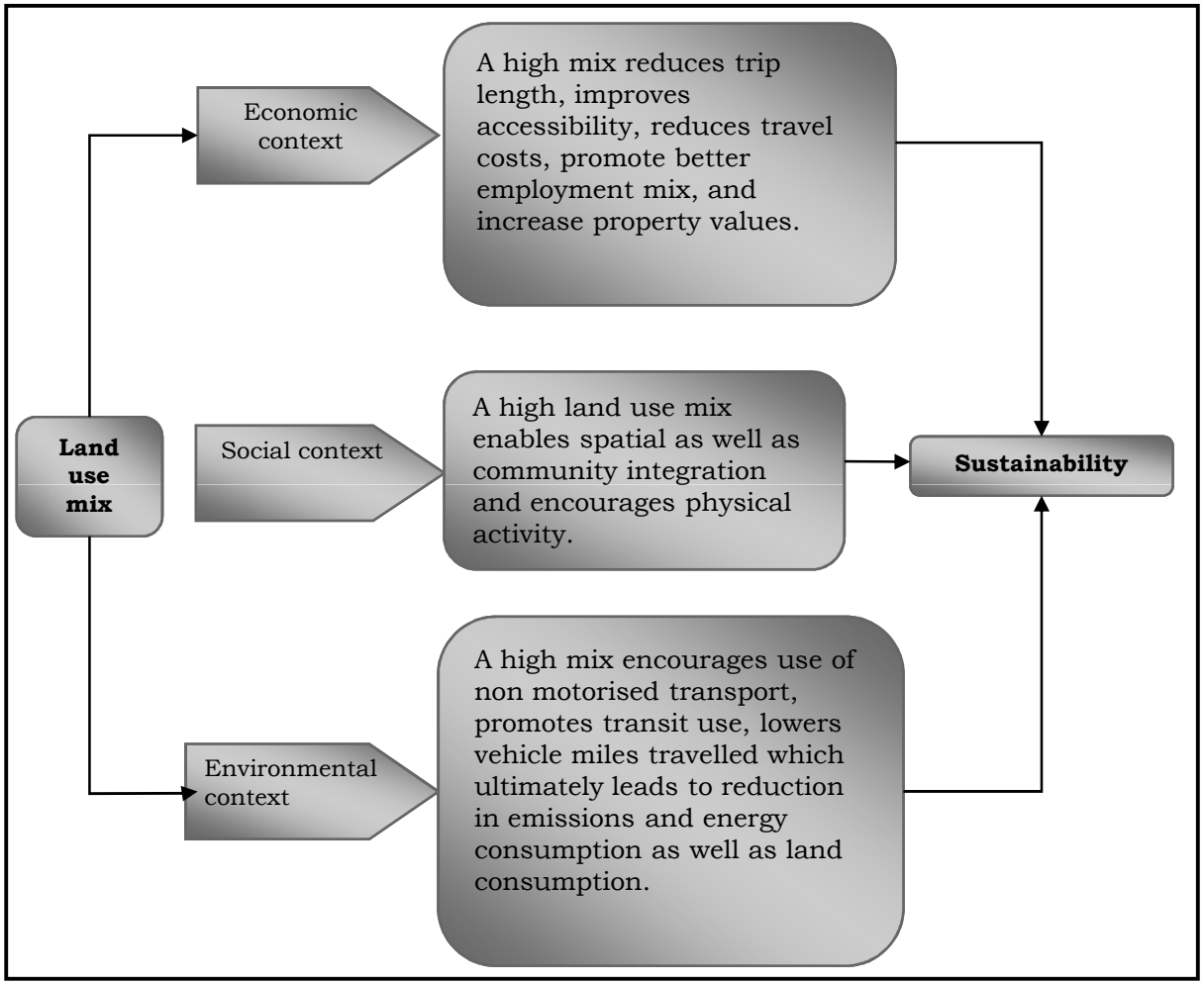
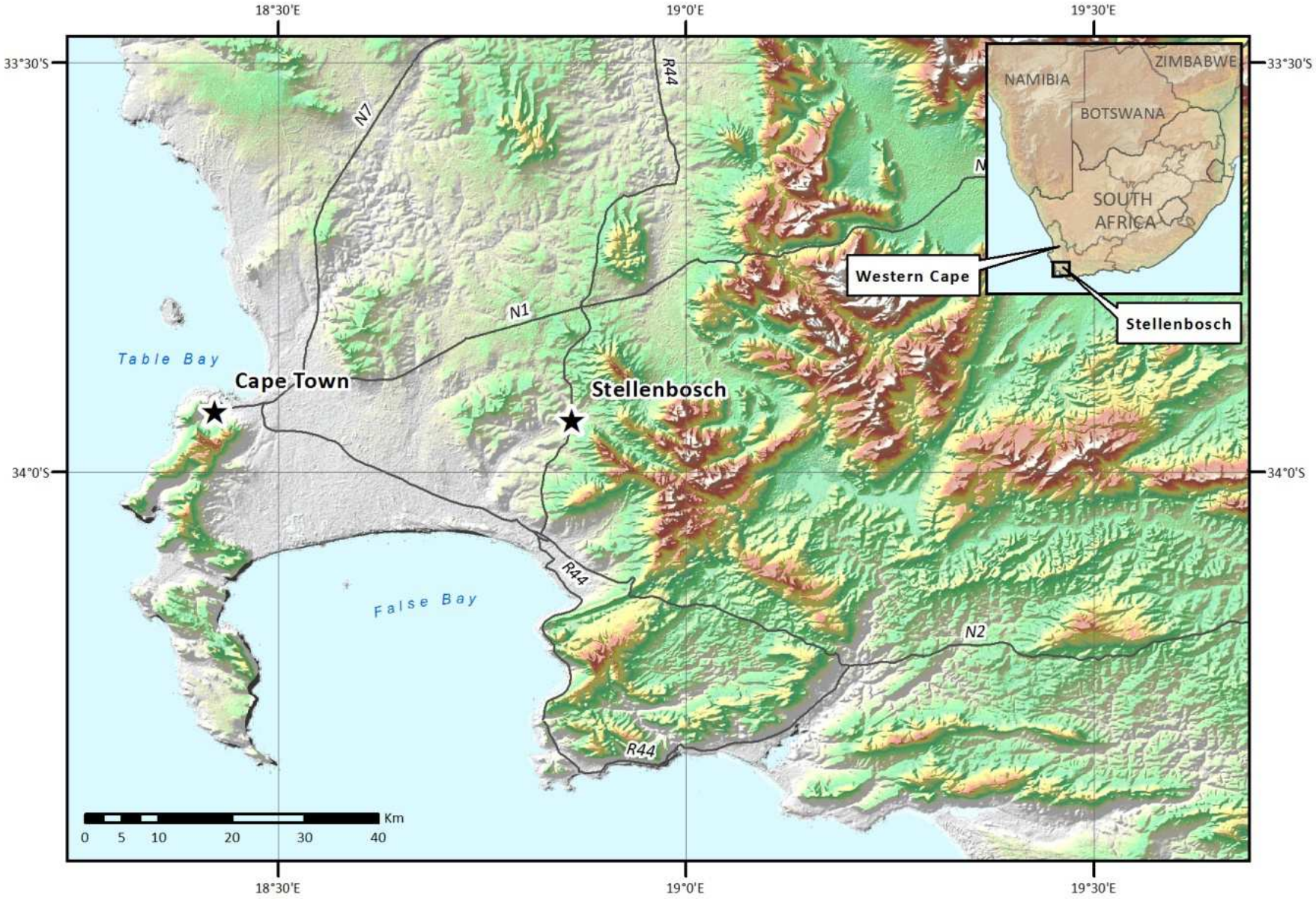


Figure 2: Impact of land use mix on sustainability. Adapted from Litman (2010), Victoria Transport Institute (2010)

Study Area: Stellenbosch, Western Cape, South Africa



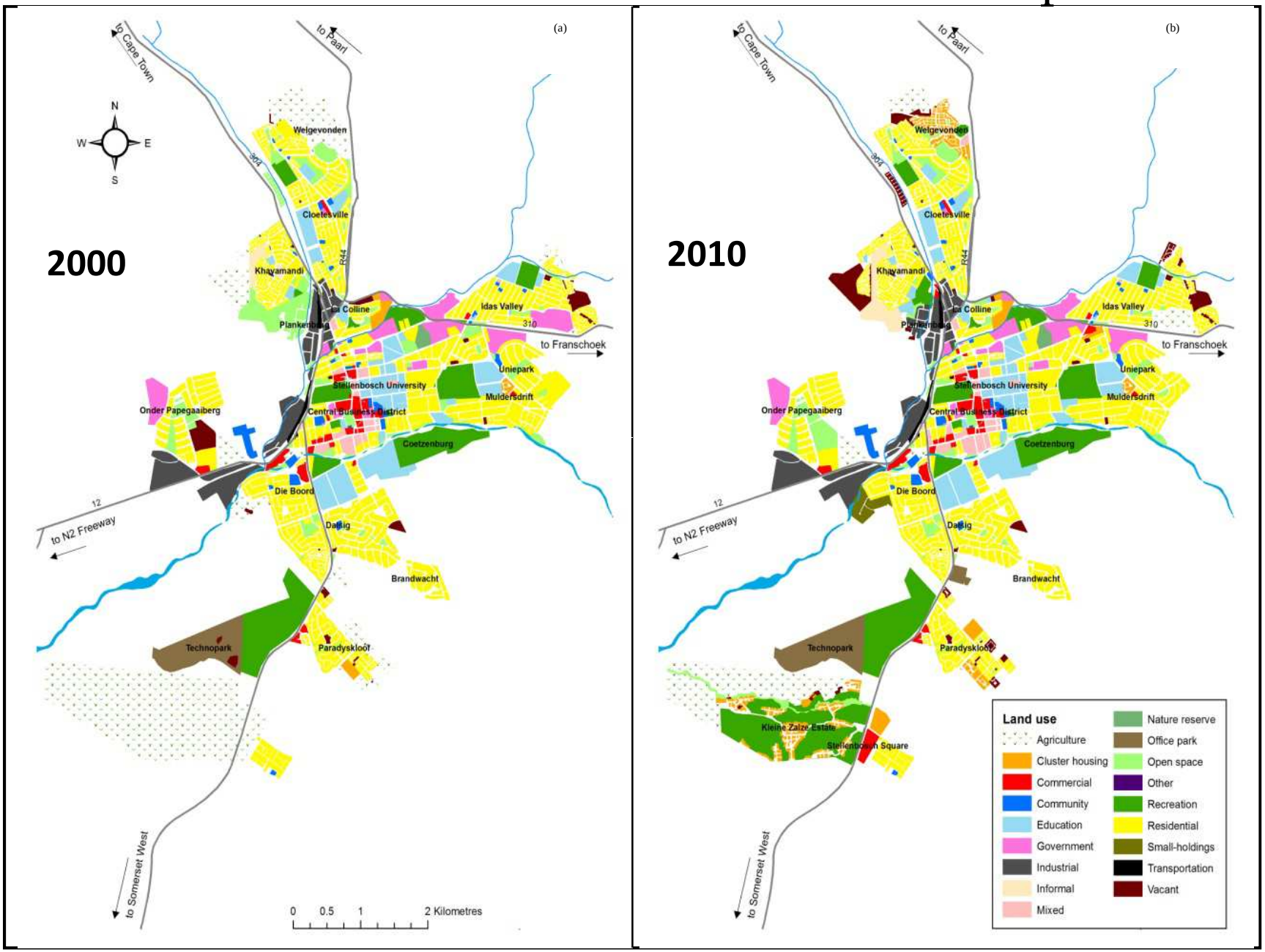
Methods: Land use mapping

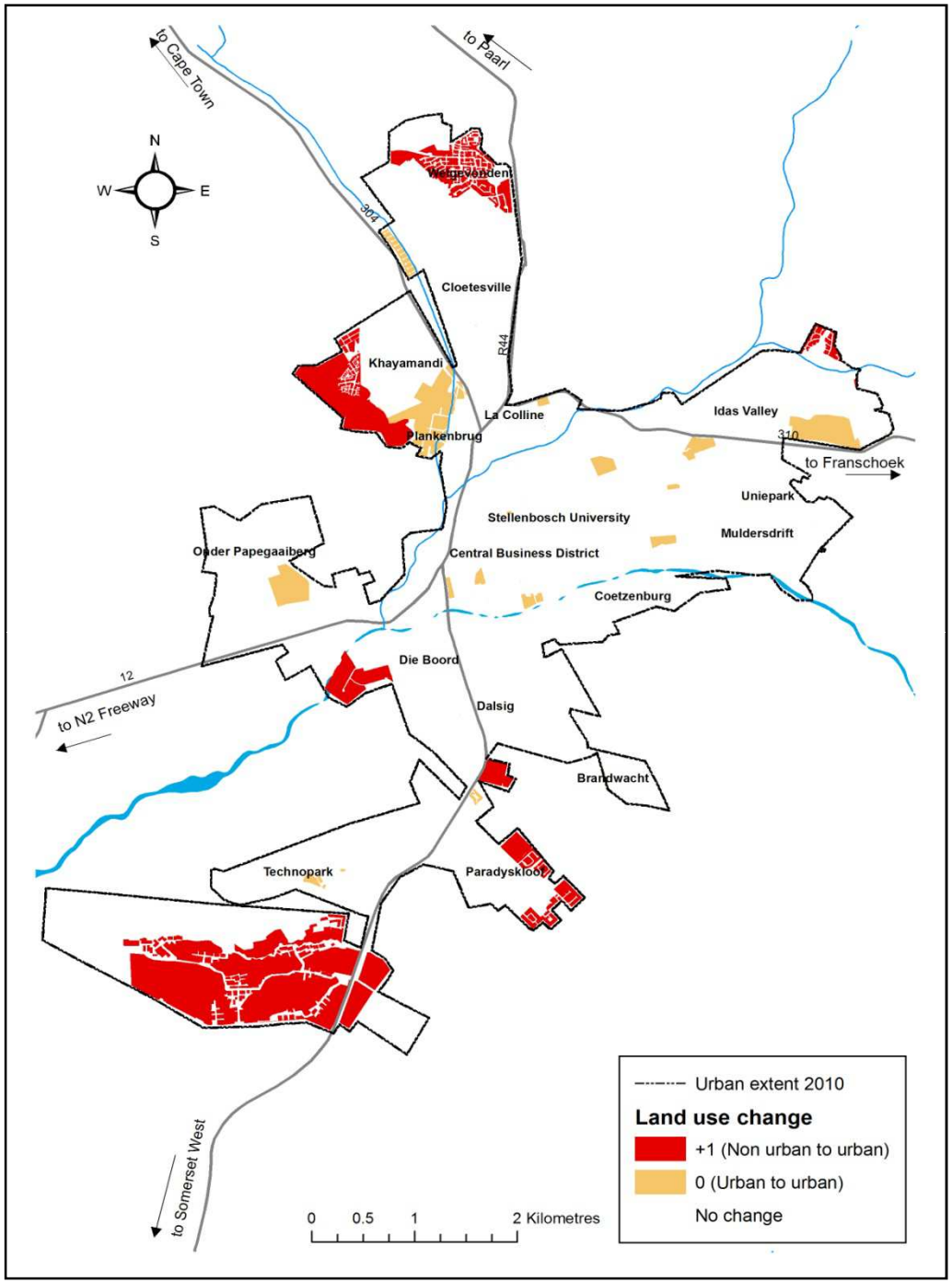
- Very high resolution (0.5m) ortho-rectified colour aerial photographs (2000 and 2010) obtained from CGA.
- Multispectral and panchromatic SPOT5 imagery for 2010, with resolutions 10m and 2.5m respectively, acquired from South African National Space Agency (SANSA).
- Spot imagery was pre-processed in PCI Geomatica
- Land cover classification was performed on the pre-processed imagery, using a supervised geographical object-based image analysis (GEOBIA) approach and eCognition software.
- Land uses classified per land parcel in ArcGIS 10 by means of a land use classification scheme adapted from (Anderson et al., 1976).
- Field visits carried out to confirm accuracy of classification.

Methods: Indicator development

- Land use maps used to derive GLUM, LLUM and LUF
- LUF and LLUM calculated in neighbourhoods of 2km x 2km in size
- Analyses were automated in the model builder tool of ArcGIS 10.

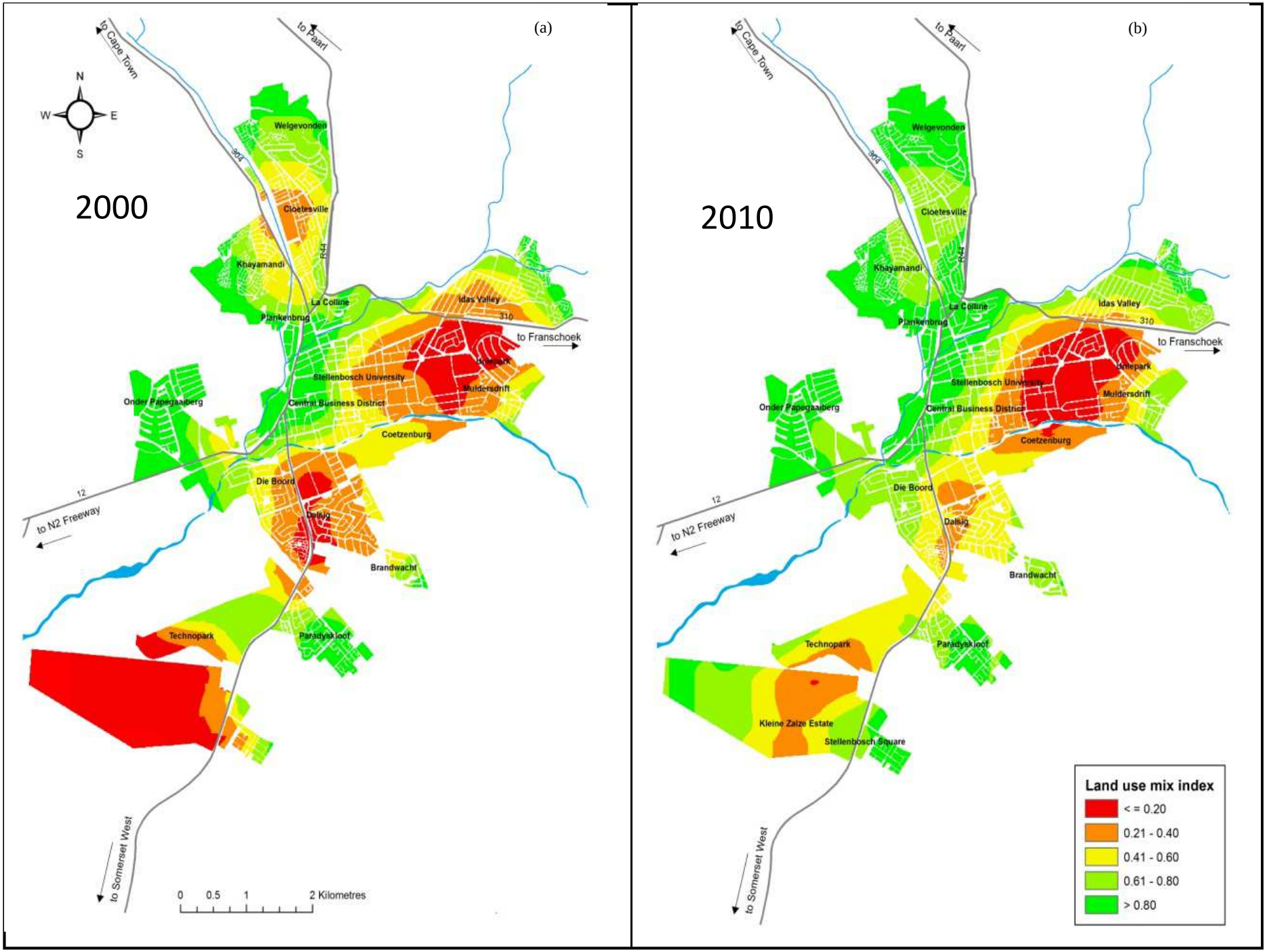
Results and discussion: Land use maps





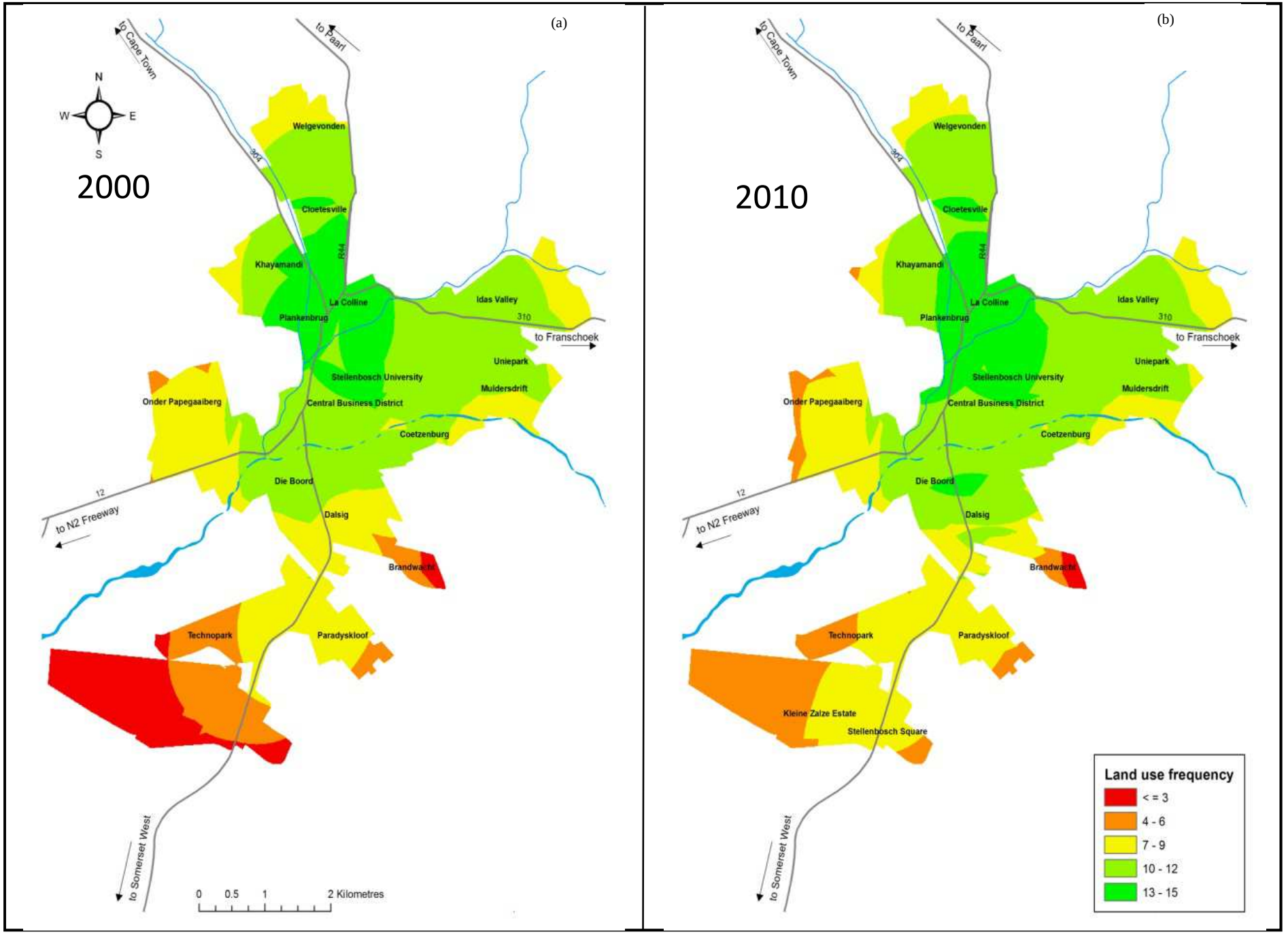
Land use change

- Most unsustainable urban change occurred in (Kleine Zalze, Khayamandi, and Welgevonden, and northern parts of Idas Valley, Paradyskloof and Die Boord).
- This is a clear indication of urban growth as it consumed pristine agricultural land and natural ecosystems.
- No change from urban to non urban.
- Urban to urban changes occurred in pockets throughout Stellenbosch.


(a)
2000
N
W
E
S
to Cape Town
to Paarl
Welgevonden
304
Cloetesville
R44
Khayamandi
La Colline
Plankenbrug
Idas Valley
310
to Franschoek
Stellenbosch University
Muldersdrift
Onder Papegaaiberg
Central Business District
Coetzenburg
Die Boord
12
to N2 Freeway
Dalsig
Brandwacht
Technopark
Paradyskloof
to Somerset West
0 0.5 1 2 Kilometres
(b)
2010
Welgevonden
304
Cloetesville
R44
Khayamandi
La Colline
Plankenbrug
Idas Valley
310
to Franschoek
Stellenbosch University
Muldersdrift
Onder Papegaaiberg
Central Business District
Coetzenburg
Die Boord
12
to N2 Freeway
Dalsig
Brandwacht
Technopark
Paradyskloof
Kleine Zalze Estate
Stellenbosch Square
to Somerset West
Land use mix index
< = 0.20
0.21 - 0.40
0.41 - 0.60
0.61 - 0.80
> 0.80

Land use mix

- High GLUM of 0.74 and 0.72 in 2000 and 2010 respectively.
- This suggests, heterogeneity, spatial integration and vibrancy.
- However high GLUM not reflective of racial integration in Stellenbosch which reflects history of spatial segregation during apartheid.
- GLUM does not show local distribution of unlike LLUM.
- Areas with low LLUM suggests lack of diversity, low spatial mix of activities and diversity which increase environmental socio-economic costs.
- LLUM indicator does not indicate urban sprawl as it increased in Kleine Zalze which was used for agriculture in 2000
- Areas with high LUMM suggest diversity, spatial integration and low social, economic and environmental costs.


(a)
2000
N
W
E
S
to Cape Town
to Paarl
Welgevonden
304
Cloetesville
R44
Khayamandi
La Colline
Plankenbrug
Idas Valley
310
to Franschoek
Uniepark
Stellenbosch University
Muldersdrift
Onder Papegaaiberg
Central Business District
Coetzenburg
12
to N2 Freeway
Die Boord
Dalsig
Brandwacht
Technopark
Paradyskloof
to Somerset West
0
0.5
1
2 Kilometres
(b)
2010
Kleine Zalze Estate
Stellenbosch Square
Land use frequency
< = 3
4 - 6
7 - 9
10 - 12
13 - 15

Land use frequency

- Slight increase in LUF from 2000 to 2010, particularly in the central and southern parts of the town
- Increase in the south attributed to Klein Zalze and Stellenbosch Square developments.
- LUF for the remainder remained constant.
- LLUM and LUF do not necessarily correspond e.g. In the CDB there is high LUF >10 but low LLUM =<0.6.
- This is because LLUM is determined by proportion of land use in a neighbourhood while LUF is land use count.
- If a neighbourhood has small spatial units dominated by one large unit LLUM will be low.
- LUF less reliable than LLUM to capture diversity, isolation and clustering of land uses.
- LLUM and LUF should not be used alone and they do not capture urban sprawl.

Practical implications and conclusions

- GLUM, LLUM, LUF assists local planning authorities to make better decisions regarding land use.
- Land use transition is an indicator of urban growth.
- LLUM and LUF help planners to produce sustainability reports that are less subjective and descriptive reports to monitor interventions.
- Indicators assist in identification of potential problem areas.
- Indexes are normalised, therefore they can be transferred to other areas and even used to compare different areas to one another.
- More research is, needed to determine how these indexes can be used in combination with other sustainability indicators.
- The advent of very high-resolution earth observation data such as GeoEye, WorldView2, and Quickbird, as well as the continuous improvement of GIS analysis tools, will certainly promote better monitoring of sustainable urban planning in developing countries.