Using geographic information system to analyse the divergence of urban development from spatial plans in Harare, Zimbabwe

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Abstract

Africa is experiencing rapid urbanisation, which calls for well-considered urban and regional planning efforts to cater for the current and future populations. However, as it is typically the case in the global South, African countries are characterised by a lack of quality spatial economic data required for planning and evaluation processes. Using the study area of Harare, Zimbabwe, the paper demonstrates ways that, amidst the paucity of data, geographic information system can be used to measure urban development's congruence with spatial plans. To prepare for the analysis, the base map preparation process entailed a laborious digitisation of hardcopy material obtained from the authorities. This was followed by land-use surveys and land-use change investigations whose data were analysed in ESRI's ArcGIS 9.3. The analysis compared urban development patterns in 2014 with the proposals of two applicable spatial plans, which were approved in 1990 and 2000 respectively. The investigations uncovered that urban development patterns and trends did not correspond with the aspirations of the plans. The paper proposes that follow-up research be conducted on factors that influence the misalignment between plans and development, particularly in African countries that are characterised by rapid urbanisation.

Keywords: *Geographic information system; evaluation of plans; Harare; spatial plans; Zimbabwe*

1. Introduction

The world is urbanising at a fast rate, to an extent that at least half of the globe's population is expected to live in urban areas by 2025 (UN-Habitat, 2010). Notably, round about half of Africa's population is urbanised, and the continent has more urban dwellers than Europe, Australasia, North America and South America (Pieterse & Parnell, 2014). Significantly, Africa's urban populace is projected to increase threefold between 2018 and 2050, with an ultimate total of about 1.5 billion urban dwellers (UN DESA, 2019). Various commentators (such as Knox & McCarthy, 2005; UN DESA, 2013) argue that although urban areas are regarded as the engine of economic growth and prosperity, they also represent the greatest concentration of challenges, which include poverty, social breakdown and environmental degradation. Against this backdrop, it stands to reason that well-considered urban and regional planning efforts are required to plan for the burgeoning urban

population in Africa. This assertion is in part informed by the argument of, among others, UN DESA (2013) that persistent urbanisation calls for changes in the way urban development is managed. It should however be acknowledged that the continent is largely characterised by a dire lack of quality spatial economic data (Gumbo *et al*., 2018; Mokhele, 2017, 2018), which can hinder planning efforts. Notwithstanding the importance of data in planning processes, there is a paucity of literature that discusses ways in which the lack of suitable spatial economic data can be circumvented towards improving urban and regional planning in Africa. To partially fill that gap, the aim of this paper is to present a foundation for using geo-spatial technology to evaluate the performance of planning in cities that are characterised by rapid urban development change. Using the study area of Harare, Zimbabwe, the specific objective of the paper is to present ways that, amidst the lack of spatial data, geographic information system (GIS) can be used to analyse urban development's congruence with spatial plans. The remainder of the paper is structured as follows: the second section provides a snapshot of the topic of evaluation of plans, followed (in the third section) by an outline of the research methods employed towards addressing the objective of the paper. The fourth section presents the analysis and findings of the study. The fifth section concludes the paper with recommendations for future research.

2. Evaluation of plans

Evaluation is a crucial component of urban and regional planning whose results can be used to, *inter alia*, enhance decision-making, improve the plan preparation process, improve the implementation of plans, and assess the effectiveness of plans (Guyadeen & Seasons, 2016, 2018). There are typically two forms of evaluation in urban and regional planning: firstly, evaluation focuses on plan quality, plan implementation, and plan outcomes. Secondly, evaluation dwells on planning processes and practices (Guyadeen & Seasons, 2018). Relatedly, it could be argued that spatial plans can take two forms, namely project plans and strategic plans. As regards project plans, once a plan is adopted, it is expected to have an effect within the timeframes set. If the effects are not realised, the plan would be regarded as at least in part unsuccessful. On the other hand, strategic plans focus on the coordination of activities and projects undertaken by various actors (Faludi, 2000). Given its focus on the congruence of urban development with the applicable spatial plans, the paper revolves around the said notions of plan quality, plan outcomes, and project plans. This focus can also be referred to as ex post evaluation, which is employed once a plan is implemented to determine whether it achieved its goals and objectives, and to use that knowledge to improve the subsequent planning efforts (Guyadeen & Seasons, 2018). In this light, the paper has a limitation of assessing the conformance of development to the applicable spatial plans without unpacking the planning processes.

3. Research methods

The paper is based on the study area of Harare, the capital of Zimbabwe. Harare was selected as a suitable focus area because it is characterised by the aforementioned lack of spatial economic data amid a plethora of challenges that emanate from rampant urbanisation. Urban areas in Zimbabwe

(and specifically in Harare) are typified by, among others, increasing informality, shrinking economy, poor infrastructure development and maintenance, social breakdown, service delivery deficiencies and inadequate land administration (Rakodi, 2006; The Economist, 2010; Owusu, 2011). One level of analysis was investigated in the study, namely Harare central business district (CBD). For the purposes of the study, Harare CBD was defined by the boundaries of Local Plan No. 17 (LP 17) and Local Plan No. 22 (LP 22). Different units of analysis were explored at various stages of the study, namely development blocks, individual plots (erven) and individual buildings.

In light of the lack of appropriate data, the base map for Harare CBD was compiled through three main interrelated steps. The first step involved the compilation of a digital geo-database from the paper copies of 1: 5000 topo-cadastral maps, which were obtained from the surveyor general's office. The maps were scanned and saved in JPEG format, followed by mosaicking (a process of electronically merging maps or images). The maps were opened in ESRI's ArcGIS 9.3, geo-referenced and saved as .mxd file named 'casestudy1'. The second step involved placing satellite imagery overlays in 'casestudy1.mxd'. 2014 satellite images were downloaded from Google Earth-Pro, saved in JPEG format, added to the .mxd file (as raster layers) and geo-referenced as overlays over the topo-cadastral information. The third step entailed obtaining paper copies of the zoning proposal maps for LP 17 and LP 22 from Harare municipality. The maps were scanned, mosaicked, added to the .mxd file and geo-referenced. The study boundaries for LP 17 and LP 22 were then combined and digitised to form the new Harare CBD study area boundary. Finally, the proposed land-use zones, reservations and planning boundaries from LP 17 and LP 22 were digitised and added as shapefiles to the Harare CBD base map. Figure 1 below is an illustration of the base map with land-use zones and planning boundaries digitised from LP 22.

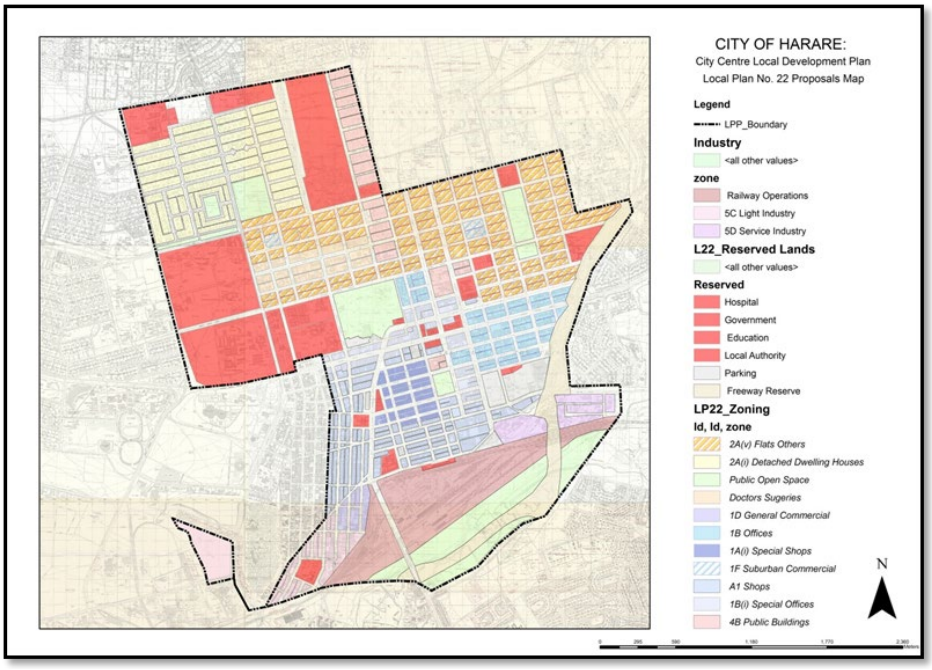

Figure 1: Harare CBD base map with LP 22 boundary and land-use proposals

4. Analysis and findings

Areas that were characterised by rapid development change in Harare CBD were marked on the base map, and adopted as the basis for conducting a preliminary land-use survey. Conducted by two research assistants, the preliminary survey entailed the confirmation of all buildings by their stand numbers, recording the number of floors per building, the nature of business conducted on each floor, and the provision of parking for the identified buildings. The findings of the survey (which showed that Harare CBD was experiencing land-use conversions instead of lateral spatial growth since it was already built-up) led to the identification of a number of development blocks for detailed land-use surveys and associated land-use change analyses whose findings are presented below.

4.1. Land-use survey 1 and change analysis

Building upon the preliminary survey, land-use survey 1 entailed the recording of existing land-use patterns in Harare CBD. The process of analysing land-use survey 1 data commenced by determining land-use classes for each stand in the development blocks surveyed. The land-use classes used were the same with those specified in either LP 17 or LP 22, depending on which planning area the land uses were located. The existing land-use maps were compared with the land-use zoning (proposal) maps using the cross-tabulation function in ArcGIS 9.3. Two blocks (blocks 19 and 22) were subsequently selected for further analysis because they had contrasting attributes as follows: on the one hand, block 19 was located in the heart of a commercial area wherein a comparison of the existing land use with the proposed (zoned) land use showed 100% compliance with the proposed land-use zoning. On the other, block 22 was situated in an area zoned for residential purposes in terms of LP 22, and showed only 25% compliance with the zoning intentions. Further findings of the investigations conducted on the two blocks are provided below.

4.1.1. Block 19

The existing land-use map showed that block 19 had maintained the original zoning aspirations of LP 22, which designated the area for ‘special shops’. GIS data manipulation tools were then used to calculate the floor area factor and the number of on-site parking bays per stand. The results were used to further measure the level of the development’s congruence with LP 22. The next form of analysis used Google Earth satellite image overlays to count off-site parking bays that served the individual plots in block 19. The results were compared with the standard for parking provision in the area, which according to LP 22 was supposed to be provided to satisfy a standard of one parking bay per 100m^2 of rentable floor space. The information on floor space calculated from satellite imagery was used to establish the prescribed number of parking bays (Table 1). This method of calculating compliance with parking standards was however subject to error when one assumed that all the floors observed from satellite image analysis were rentable floor space. Some floor space could have for instance been occupied by parking garages and service ducts, which cannot be classified as rentable space. Ground verification was therefore used to confirm or rectify the assumption.

Table 1: Parking information for block 19

Ref. No.	Floor area (m^2)	Prescribed parking bays	Existing Parking Bays	Difference
0	12365	123	13	-110
1	8755	87	10	-77
2	3670	36	0	-36
3	4228	42	2	-40
4	1143	11	12	+1
5	2560	25	8	-17
6	3458	34	8	-26
7	1676	16	6	-10
8	1246	12	15	+3
9	3813	38	11	-27
10	3358	33	5	-28
Total		**457**	**90**	**-367**

Table 1 shows a significant deficit in the provision of parking when measured against the prescriptions of LP 22. There were only 90 off-site parking bays out of a possible total of 457, representing 20% compliance. These figures pose questions on the accuracy and appropriateness of both the predictive and forecasting techniques used in either the formulation of parking standards or the application of development conditions in land-use management processes.

4.1.2. Block 22

Block 22 comprised 12 plots, which were part of 'Zone 2 (i): detached dwelling houses' in accordance with LP 22 (yellow colour in Figure 2). The findings of the analysis showed that only three buildings on residential stands (out of the original number of 12) were compliant with the intended zoning. The block subsequently comprised seven offices stands, two medical facility stands and three residential stands. Using ArcGIS 9.3, this new pattern was edited onto a shapefile exported from the block 22 shapefile. A satellite image of the area was also downloaded from Google Earth Pro, and overlaid onto the existing land-use file for further analysis (Figure 2).

Figure 2: Block 22 land-use change

The maps were then juxtaposed for visual comparison purposes. The yellow colour on the second plate of Figure 2 represents the three residential stands that retained their zoned land use whilst the light blue and light pink colours represent the seven office stands and the two medical stands respectively. Having characteristics of footprint analysis (Pillay & Geyer, 2016; Mokhele, 2018), the building footprints (observed from the 2014 satellite image for the block) were digitised and represented by features that are coloured dark pink in Figure 2. The data from the attribute tables of the two maps were cross-tabulated in order to conduct a detailed land-use change analysis (Table 2).

Table 2: Land-use change data analysis for block 22

	Zoned Area (m^2)	Gain/Loss from 2A(i) Detached Dwelling Houses	Gain/Loss from 1B Offices	Gain/Loss from 3A Doctors Surgeries	Current Area (m^2)
2A(i) Detached Dwelling Houses	30419.38	0	-17821.47	-4967.52	7630.39
1B Offices	0	+17821.47	0	0	17821.47
3A Doctors Surgeries	0	+4967.52	0	0	4967.52

Table 2 shows that the area earmarked for residential purposes in block 22 had declined to 7 630m^2 in 2014 (at the time of land-use survey 1) from 30 419m^2 in 2000 (when LP 22 was approved), representing 25% compliance with the zoning plan. This arguably showed that the planners had failed to anticipate massive land-use change in the residential zone. The other variable that was used to measure the plan compliance was site coverage. Existing buildings were digitised from the 2014 Google Earth satellite image. The building areas were measured and calculated (in ArcGIS 9.3) from the attribute table of the resultant buildings' shapefile. Data from the attribute tables of the buildings

shapefile and the existing land-use file were exported to Microsoft Excel for further analysis (Table 3). The percentages of the building areas over stand areas were then calculated, and the results were recorded in column 6 of Table 3.

Table 3: Block 22 attribute data

Stand No.	Zone	Stand Extent	Building Area	No. of Buildings	Site Coverage
3000	1B Offices	2655.84	574.02	1	21.61%
3001	2A(i) Detached Dwelling Houses	2582.22	203.96	1	7.90%
3002	2A(i) Detached Dwelling Houses	2595.09	227.71	1	8.77%
3003	1B Offices	2661.85	289.22	2	10.87%
3004	1B Offices	2498.65	263.12	2	10.53%
3005	1B Offices	2563.6	289.6	1	11.30%
3006	1B Offices	2563.38	905.93	5	35%
3007	3A Doctors Surgeries	2402.95	439.04	2	18.27%
3008	1B Offices	2481.37	259.61	2	10.46%
3009	2A(i) Detached Dwelling Houses	2453.08	270.9	1	11.04%
3010	3A Doctors Surgeries	2564.57	267.25	1	10.42%
3011	1B Offices	2396.78	381.82	3	15.93%
TOTAL		30419.38	4372.18		
	AVERAGE			1.73	14.34%

The key finding is that there was 100% compliance with the development condition in LP 22, which stipulated that the maximum site coverage of the buildings be 35% of the stand. The question that arises is the appropriateness of a 35% maximum site coverage condition in an area that was predominantly occupied by office and medical buildings. It could be argued that the standard was meant to preserve and enhance privacy, exclusivity and high property values through the provision of lavish garden spaces for low-density residential areas. The same principles were less likely to be applicable in an offices zone that could be more influenced by the need to increase rentable floor space, a condition that could necessitate the reduction of the garden space to the minimum.

4.2. Land-use survey 2 and change analysis

The foregoing land-use survey results were used to identify four sample areas for detailed land-use change analyses. Selection of the four areas was done in a manner that ensured diversity between the samples, implying that each sample was predominantly zoned for a land-use group that was different from the other samples as follows: sample 1 (commercial); sample 2 (residential flats); sample 3 (detached housing); and sample 4 (flats and educational). For the second land-use survey, the units of analysis were development blocks whose boundaries were defined by roads. The observed land-use patterns were plotted on a map using the reclassified land-use scheme, followed by the comparison of existing land use with the proposed land use using change detection and cross tabulation techniques in ArcGIS 9.3. The process is summarised in Table 4.

Table 4: Land-use change analysis process

ACTIVITY	INPUT	METHOD/ TOOL	OUTPUT
Planned land-use classification	LP 17 & LP 22	Merging LP 17 & LP 22 shapefiles & editing attribute tables	Combined land-use zoning map
Creating separate shapefiles for sample areas' zoned uses	Combined land-use zoning map	Exporting selected data for sample areas	Sample areas shapefiles for zoned uses
Existing land-use classification	Land-use survey findings	Microsoft Excel tabular analyses	Existing land-use classes for sample areas tables
Creating separate shapefiles for sample areas' existing land uses	Sample areas shapefiles for zoned uses & existing land-use classes for sample areas tables	Exporting data from shapefiles & editing attribute tables of the exported files	Sample areas shapefiles for existing land uses
Rasterisation and cross-tabulation	Sample areas shapefiles for zoned uses & sample areas shapefiles for existing uses	Converting the two sets of sample maps from vector to raster and cross-tabulation	Land-use change maps and .dbf tables depicting the areal extent of land-use change

As depicted above, the first part of the exercise involved combining the two zoning maps for LP 17 and LP 22. This was done through merging (in ArcGIS 9.3) the two local plan shapefiles to produce a new shapefile named 'zoning_merge_map'. The attribute table of this new shapefile was then edited to include a new field named 'land use', which provided standardised land-use categories to facilitate the reclassification of the land-use zones into broader land-use classes (Table 5). Standard classes were created to enable analysis of change from common land-use categories.

Table 5: Land-use block classification scheme

ACTIVITIES	LAND USE CLASSIFICATION
Shops	COMMERCIAL
Offices	
Restaurants	
Guest Houses	RESIDENTIAL
Detached Residential	
Residential Flats	FLATS
Doctors' Surgeries	MEDICAL
Clinics	
Hospitals	
Medical Laboratories	
Funeral Parlours	FUNERAL
School	EDUCATIONAL
Crèche	
Training Centre	
Church	PUBLIC BUILDINGS
Community Hall	
Public Buildings	
Government Offices	GOVERNMENT
Local Authority Offices	
Where uses other than the predominant use constitute 50% or more when measured against the total uses.	MIXED USE

In light of the land-use classes above, analysis table for land-use change analysis (Table 6) was devised to aid the analysis of the sample areas (refer to the Appendix).

Table 6: Land-use change analysis table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Block No.	Residential	Flats	Medical	Guest Houses	Shops	Restaurants	Office	Funeral	Church	Education	Other	Predominant Use	% Mix	Classification

For each sample, the sums of the land-use categories recorded in columns A to K (as shown in Table 6) were added, and the answer divided by the values in the predominant use column multiplied by 100. This was done to derive the percentages of land-use mix per development block, which were recorded in column M. The values recorded in column M were thus calculated using the following equation:

$$M = \frac{(\sum \mathrm{n} - \mathrm{L})\ 100}{\sum n} \quad [1]$$

Where:

M represents the percentage of land-use mix.

$\sum n$ represents the sum of the values of all land uses as indicated in columns A to K.

L represents the value of the predominant use.

Where the value of M was 50% or more, the development block was classified as a mixed-use; and where the value of M was below 50%, the block was allocated the 'predominant use' zone.

4.2.1. Sample 1 (commercial area)

Sample 1 was mainly zoned for shops and offices in terms of LP 17. These two uses were then classified under the commercial land-use class in terms of the broad land-use classification scheme. The other land-use zones in the area included proposals to establish a bus terminus and a parking garage, which were placed under the land-use class of transport. A physical land-use survey was then conducted to confirm the existing land uses. The land parcels that were part of individual development blocks defined by street boundaries were adopted as units of analysis for the survey. Two maps for sample 1 were created through exporting 26 land parcels from 'zoning_merge_map' referred to earlier. One of the maps was named 'zoned land use map for sample 1', with 24 land parcels in the commercial land-use class and two in the transport class (Figure 3). The second map's attribute table was edited to align with the land-use classification carried out after the analysis of land-use survey data outlined in Table 5, and it was named 'land use survey 2 sample 1 existing land use map'. The latter consisted of two land-use classes: the commercial zone and the mixed land-use zone. Four land parcels classified as commercial (first plate on Figure 3) changed to mixed use whilst the two transport parcels changed to commercial (middle plate on Figure 3).

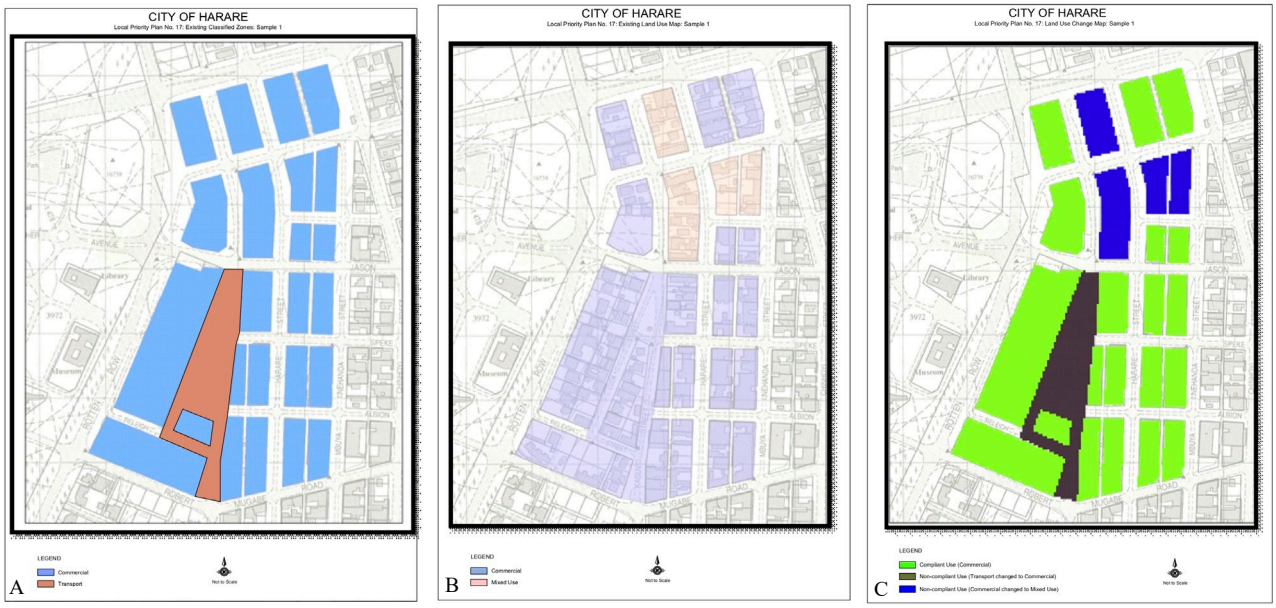

Figure 3: Land-use change maps for sample 1

The three maps were juxtaposed to facilitate a visual comparison of land-use change from the zoning proposal to the existing land use. The first two plates on Figure 3 were converted from vector to raster format and cross-tabulated in ArcGIS 9.3 for the purposes of carrying out a mathematical differentiation of land-use change. The visual result of the cross tabulation exercise came out in the form of a single land-use change map (third plate on Figure 3). The map depicts the commercial areas that were not affected by change in green; the transport zone (which changed to commercial) in black; and the commercial areas (which changed to mixed use) in blue. The mathematical data obtained from the cross tabulation were then summarised and presented in a tabular format, which quantified the spatial land-use change in terms of extent (m^2) as displayed in Table 7.

Table 7. Land-use change summary for sample 1

Land use	**Zoned Area (m^2)**	**Gain/ Loss from Commercial (m^2)**	**Gain/ Loss from Transport (m^2)**	**Gain/ Loss from Mixed Use (m^2)**	**Current Area (m^2)**
Commercial	108154.26	0	+18569.59	-17521.99	109201.79
Transport	18569.92	-18569.92	0	0	0
Mixed use	0	17521.99	0	0	17521.99

The values in Table 7 show that the area earmarked for commercial purposes marginally increased from 108 154m^2 in 1990 to 109 201m^2 in 2014. The entire 18 569m^2 reserved for the development of a bus terminus and parking garage was taken up by commercial activities whilst 17 521m^2 changed from commercial to mixed use. These results show that the proposal to create a transport zone in the area did not materialise in the 14 years that the plan had been in place. The findings also reflect the emergence of a new mixed use class, which took up 17 521m^2 from 108 154m^2 originally zoned for commercial purposes.

4.2.2. Sample 2 (residential flats area)

The maps for sample 2 were created through extracting data from 'zoning_merge_map' using the procedure outlined for sample 1. The extracted data were made up of 48 land parcels wherein the zoned land-use map for the area showed that LP 22 had designated one land parcel for commercial purposes, six for community use, 26 for flats and 15 for medical purposes. The units of analysis for this sample were development blocks, which were defined by access roads as boundaries. This meant that in certain instances, land parcels that were only divided by a narrow service lane would be referred to as a block. There were however exceptions where a service lane also formed the demarcation between land-use zones. In the latter instance, the units of analysis were based on the differently zoned land parcels (Figure 4). Against this backdrop, sample 2 ended up with 24 blocks being defined as the units of analysis. The second map was then edited to align with the classified land uses in the analysis table for sample 2 (first plate of Figure 4).

Figure 4: Land-use change maps for sample 2

The maps were juxtaposed for visual comparison, which showed that land-use change resulted in a new class of mixed use that occupied 11 blocks. The other significant change was that the number of commercial blocks increased from one to two, the medical blocks and the community blocks decreased from ten to two and three to zero respectively. The features represented on plates 1 and 2 on Figure 4 were converted to raster format using ArcGIS 9.3, and compared using the 'math and minus' command. The resultant map, which depicts the land-use change, is shown on the third plate on Figure 4. The plate reflects that there was a massive land-use change with only 12 (in red) out of 48 land parcels in the sampled area retaining their zoned land uses. The attribute data extracted from the cross-tabulation of the land-use change maps were quantified and compared (Table 8). Most of the land-use change in the area was in the form of the conversion of the zoned medical and flats land parcels into mixed use, which subsequently gained 223 111m^2 from the two land-use classes. The other land-use class that increased in size was the commercial zone, which gained 7 022m^2 from the

flats zone. The community, flats and medical zones lost 64 717m^2, 34 899m^2 and 130 517m^2 respectively.

Table 8: Summary of land-use change in sample 2

LAND USE	ZONED AREA (m^2)	EXISTING AREA (m^2)	CHANGE (m^2)
Commercial	10224.4	17246.53	+7022.13
Community	64717.2	0	-64717.2
Flats	254396.02	219496.46	-34899.56
Medical	151914.35	21397.10	-130517.25
Mixed use	0	223111.88	+223111.88

4.2.3. Sample 3 (detached housing area)

Maps for the third sample were created using the same procedure utilised for samples 1 and 2. Similarly, the units of (land-use change) analysis for this sample were development blocks, which were defined by access roads as boundaries. As noted before, this implied that in some instances, two or more land parcels that were divided by narrow service lane were considered as a single block. There were however exceptions where the service lane also formed the demarcation between two distinct land-use zones. In such instances, the units of analysis were based on the differently zoned land parcels (first plate on Figure 5). Sample 3 ended up with 12 blocks that were used as units of analysis. The second map was then edited to align with the classified land uses in the analysis table for sample 3 (second plate on Figure 5). In comparing the two maps, the magnitude of land-use change is clear with the most visible being the conversion of six land parcels from residential use to mixed-use, as well as the conversion of the educational area into a mixed-use area.

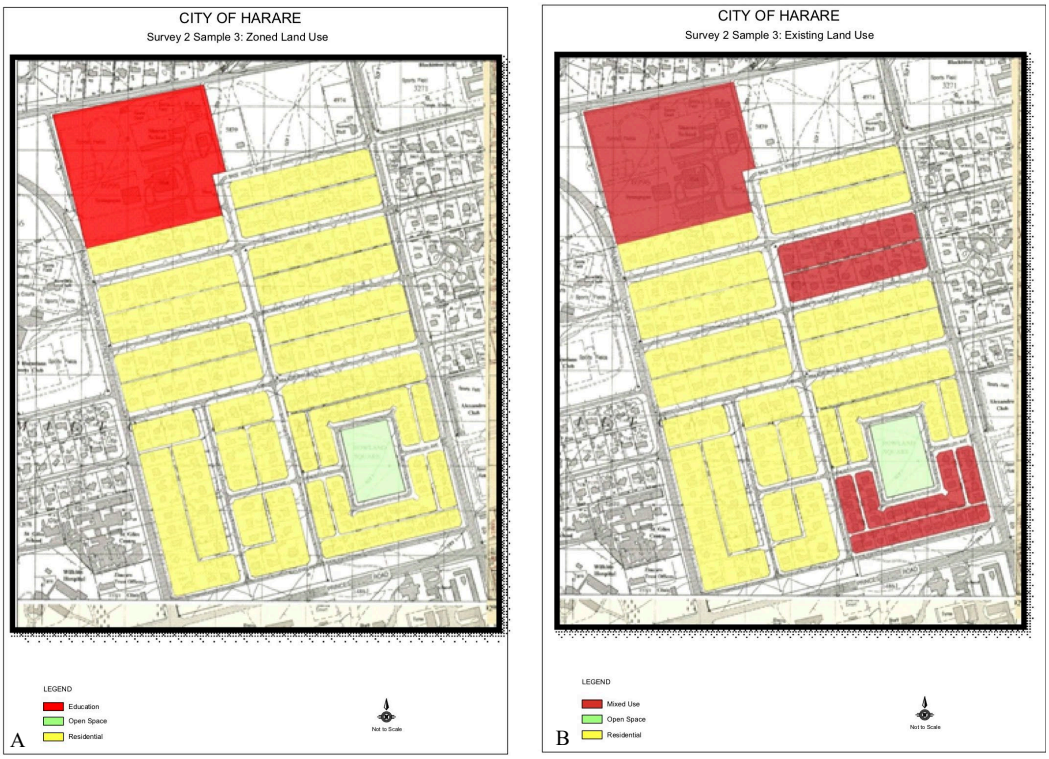

Figure 5: Land-use change maps for sample 3

A cross tabulated comparison of the zoning and the existing land-use maps for sample 3 was then conducted using blocks as units of analysis, and saved under the name 'land use change map for sample 3'. The summarised version of the values depicting land-use change extracted from the attribute table of the land-use change map is presented in Table 9. It shows that the educational and the residential zones lost 96 712m^2 and 75 087m^2 respectively to the mixed use zone. The open space zone remained unchanged at 17 139m^2.

Table 9: Summary of land-use change in sample 3

LAND USE	ZONED AREA (m^2)	EXISTING AREA (m^2)	CHANGE (m^2)
Education	96712.8	0	-96712.8
Open space	17139.5	17139.5	0
Residential	389212.74	314125.09	-75087.65
Mixed use	0	171800.45	171800.45

4.2.4. Sample 4 (flats and educational area)

The same procedure for land-use change analysis used for samples 1, 2 and 3 was applied towards analysing sample 4. Figure 6 demonstrates the land uses as per LP 22 zoning and land-use survey respectively. The information on the first plate shows that LP 22 zoned 26 land parcels for flats, one for educational, one for government and two for open space. A comparative analysis of the current situation as depicted on the first plate on Figure 6 shows that all land parcels that had been zoned for flats had changed to either mixed use or commercial, which implied that there was 0% compliance with the 'flats' zoning proposal. The only uses that retained their zoned classes in the area were those whose ownership was vested in the government, namely educational, government reserve and public open spaces (second plate on Figure 6).

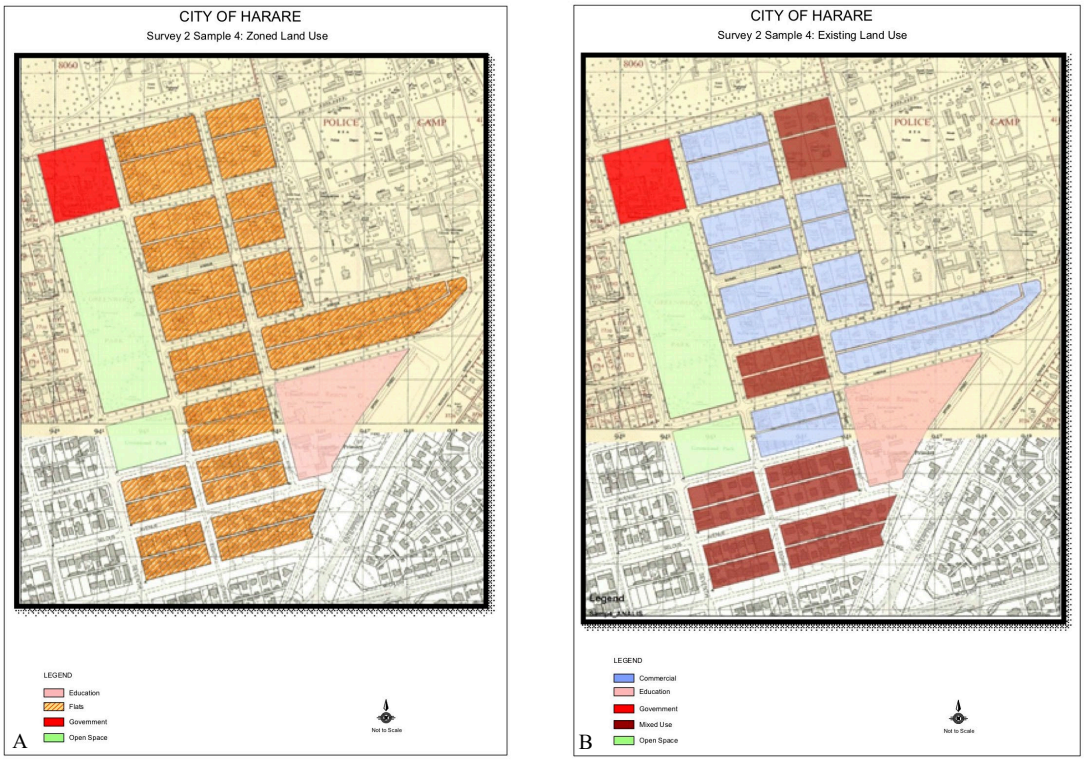

Figure 6: Land-use change maps for sample 4

A mathematical comparison of the figures from the attribute tables of Figure 6 is presented in Table 10. The values show that the flats zone lost 160 569m^2 and 103 690m^2 to the commercial zone and mixed use respectively. These inconsistencies between the zoning proposals and existing land use point towards the inability of planners to anticipate the change in market demands.

Table 10: Summary of land-use change in sample 4

LAND USE	ZONED AREA (m^2)	EXISTING AREA (m^2)	CHANGE (m^2)
Education	41766	41766	0
Flats	264259	0	-264259
Government	23956.5	23956.5	0
Open space	77288.8	77288.8	0
Commercial	0	160569.01	+160569.01
Mixed use	0	103690.22	+103690.22

5. Conclusion

African countries are experiencing exponential urbanisation, which is likely to continue unabated in the foreseeable future. This state of affairs calls for well-considered urban and regional planning efforts, including the evaluation of planning to yield the intended results. Countries of the global South (including those in Africa) are however characterised by a dire lack of quality spatial economic data requisite for meaningful planning and evaluation processes. Amid the paucity of data, the paper used the study area of Harare, Zimbabwe, to demonstrate ways in which GIS can be used to measure urban development's congruence with spatial plans. Through land-use surveys and land-use change investigations conducted in ArcGIS 9.3, it was discovered that urban development patterns in Harare CBD were largely not aligned with the aspirations of the applicable spatial plans. For instance,

detailed land-use change analyses in the four sample areas showed an increasing demand for the previously unanticipated land-use class of the so-called mixed use. It is hoped that the methods presented herein can be tested in different contexts so that they could be improved upon, and be used as the basis for analysing land-use change in towns, cities and regions with paucity of spatial economic data. Though the findings are insightful in their own right, it is acknowledged that the paper does not describe or explain the reasons behind urban development's poor alignment with spatial plans. In the light of this apparent limitation, it is hoped that future research would delve deeper into the topic and unravel the factors that influence the patterns of misalignment uncovered.

6. References

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APPENDIX

Sample 1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Block No.	Residential	Flats	Medical	Guest Houses	Shops	Restaurants	Office	Funeral	Church	Education	other	Predominant Use	% Mix	Classification
1	0	0	0	0	1	0	5	0	0	1	0	Office	29%	Commercial
2	0	0	1	0	3	2	2	1	0	0	1	Shops	70%	Mixed Use
3	0	0	1	0	3	0	5	1	0	0	1	Office	44%	Commercial
4	0	0	0	0	0	0	2	0	0	0	0	Office	0%	Commercial
5	0	0	0	0	8	1	4	3	1	0	1	Shops	53%	Mixed Use
6	0	0	3	0	7	3	3	1	0	0	0	Shops	59%	Mixed Use
7	0	0	0	0	22	2	0	0	0	0	1	Shops	12%	Commercial
8	0	0	0	0	10	0	1	1	0	0	2	Shops	29%	Commercial
9	0	0	2	0	15	1	1	0	0	0	1	Shops	25%	Commercial
10	0	0	0	0	4	0	10	0	0	0	0	Office	29%	Commercial
11	0	0	0	0	20	1	1	0	0	0	0	Shops	9%	Commercial
12	0	0	1	0	15	0	1	0	0	0	0	Shops	12%	Commercial
13	0	0	1	0	12	1	1	0	0	0	0	Shops	20%	Commercial
14	0	0	0	0	12	1	6	2	0	0	0	Shops	43%	Commercial
15	0	0		0	14	0	3	0	1	0	0	Shops	22%	Commercial
16	0	0	0	0	20	1	0	0	0	2	1	Shops	17%	Commercial
17	0	0	0	0	15	3	1	0	0	0	1	Shops	25%	Commercial
18	0	0	0	0	25	0	6	0	0	0	1	Shops	22%	Commercial
19	0	0	0	0	24	1	3	0	0	0	2	Shops	20%	Commercial
20	0	0	0	0	27	1	0	0	0	1	2	Shops	13%	Commercial
21	0	0	0	0	21	2	1	0	0	0	2	Shops	19%	Commercial

Sample 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Block No.	Residential	Flats	Medical	Guest Houses	Shops	Restaurants	Office	Funeral	Church	Educational	Other	Predominant Use	% Mix	Classification
1	0	3	3	1	2	0	0	0	1	1	0	Flats/ Medical	73%	Mixed Use
2	1	4	0	0	0	0	3	0	0	0	0	Flats	50%	Mixed Use
3	0	4	0	0	0	0	2	0	0	0	1	Flats	43%	Flats
4	4	5	4	0	0	0	2	3	1	0	1	Flats	75%	Mixed Use
5	2	5	2	0	0	0	0	0	0	0	0	Flats	44%	Flats
6	1	2	1	2	0	0	4	3	0	0	0	Office	69%	Mixed Use
7	2	1	2	0	0	0	1	0	0	0	0	Residential/ Medical	67%	Mixed Use
8	0	3	3	0	0	0	0	0	0	0	0	Flats/ Medical	50%	Mixed Use
9	1	6	1	0	0	0	5	0	0	0	1	Flats	57%	Mixed Use
10	0	2	3	1	0	0	0	0	0	0	1	Medical	57%	Mixed Use
11	0	7	1	0	1	0	0	0	0	1	1	Flats	30%	Flats
12	4	2	4	1	1	0	0	0	0	0	0	Residential/ Flats	66%	Mixed Use
13	0	6	1	0	0	0	1	0	0	0	1	Flats	25%	Flats
14	0	10	1	0	0	0	1	0	0	0	0	Flats	9%	Flats
15	0	0	4	0	0	0	1	0	1	0	0	Medical	33%	Medical
16	0	9	3	0	0	0	2	0	0	0	0	Flats	36%	Flats
17	1	5	2	0	0	0	1	0	0	0	0	Flats	44%	Flats
18	1	5	1	0	1	0	0	0	0	0	0	Flats	38%	Flats
19	0	7	0	0	0	0	0	0	0	0	0	Flats	0%	Flats

20	0	1	0	1	4	0	0	0	1	1	1	Shops	50%	Commercial
21	3	8	1	0	2	0	3	0	1	0	0	Flats	56%	Mixed Use
22	1	6	0	0	0	0	1	0	0	0	0	Flats	25%	Flats
23	0	8	0	0	0	0	1	0	0	0	0	Flats	11%	Flats
24	1	5	2	0	2	0	1	0	0	0	1	Flats	58%	Mixed Use
TOTAL	22	114	39	6	13	0	29	6	5	3	8			
Average													44%	

Sample 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Block No.	Residential	Flats	Medical	Guest Houses	Shops	Restaurants	Office	Funeral	Church	Educational	Other	Predominant Use	% Mix	Classification
1	17	0	2	0	0	0	4	0	0	2	0	Residential	32%	Residential
2	6	0	0	0	0	0	3	0	0	0	0	Residential	33%	Residential
3	11	0	0	0	0	0	2	0	0	0	0	Residential	15%	Residential
4	18	0	3	0	0	2	13	0	0	0	0	Residential	50%	Mixed Use
5	18	0	1	0	0	1	15	0	0	0	0	Residential	49%	Residential
6	11	0	0	0	0	0	5	0	0	0	0	Residential	31%	Residential
7	11	0	0	0	0	0	5	0	0	0	0	Residential	31%	Residential
8	11	0	1	0	0	0	4	0	0	0	0	Residential	31%	Residential
9	7	0	1	0	0	1	8	0	0	0	0	Office	53%	Mixed Use
10	9	0	0	0	0	1	6	0	0	0	0	Residential	44%	Residential
11	6	0	0	0	0	0	2	0	0	0	0	Residential	25%	Residential
12	0	0	0	0	0	0	0	0	1	2	3	Education	50%	Mixed Use
TOTAL	125	0	8	0	0	5	67	0	1	4	3			
AVERAGE													37%	