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Peri-urbanization landuse dynamics: an analysis of evolving patterns and their impacts on Gabane Village, Botswana

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Abstract This case study investigates peri-urban land-use conflicts and changes, in a typical African setting, for a village located on the outskirts of the capital city of Gaborone-Botswana, in order to explore policy implications for sustainable core-region development. The year 1982 provided the baseline situation that was compared with other dates, namely: 1996; 2006 and 2012 in order to analyze land-use conflicts, competition, and succession. The study tracked the landuse changes using: Geographic Information System (GIS), with 1:50 000 air photos taken in 1982; Landsat images from 1996 and 2006 as well as 2012 Google images of medium resolution. The investigation also relied on a social survey, historical landscape reconstruction approaches, field interviews and direct observations. An analysis of 1982 aerial photographs revealed that Gabane Village had experienced little urban influence from the city of Gaborone at that time. Subsequently, stakeholders with different socio-economic demand emerged. This caused extensive land-use changes over the study period. The residents of Gabane nonetheless employed diverse adaptive strategies to sustain their livelihoods. An analysis of the proposed 2001-2025 Development Plan for Gabane Village, identifies possible future land-use changes and conflicts and proposes tentative policy solutions for the emerging sustainable development challenges.

Keywords Botswana · Peri-urbanization · Sustainable city-region environment

Introduction

In Botswana, an urban settlement is defined by a minimum threshold population of 5 000 residents with at least 75 percent of its economically active population engaged in non-agricultural activities. Unlike most sub-Saharan African countries, over half of Botswana's population currently lives in urban settlements (Statistics Botswana 2011). The urbanization process in Botswana can be attributed to three factors. First, the number of places designated urban, has been increasing due to the reclassification of former traditional agro-towns (Gwebu 2004). The other important impetus to urbanization has been rapid rural–urban migration (Bryant et al. 1978; Statistics Botswana 2011). The national population is responding to private and public sector investment patterns and their associated economic and socioeconomic opportunities that are located in towns and cities (Hope and Edge 1996). Moreover, the chronic drought conditions of the 1980s forced rural communities to relocated to large settlements where water and drought relief programs were more

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accessible (Gwebu 2000). Also returning migrants from South Africa, due the discovery and exploitation of minerals, provided the miners with ideal employment opportunities in the mining towns (Silitshena 1984, 1996). Finally, the strategic location of settlements has also provided a basis for their growth (Gwebu 2003). This has been in terms of their relative positioning with regard to major transportation routes and centers of industrial, commercial and administrative functions such the dormitory and peri-urban settlements of Gaborone (Gwebu 2004).

Contemporary research on the urban situation in sub-Saharan Africa has focused on urbanization trends and their attendant in situ challenges such as: dysfunctional land markets; metropolitan management challenges; unemployment; shortage of housing; inadequate power, transport and communication facilities; insufficient water and sanitation; and environmental pollution (Hove et al. 2013).

Relatively, fewer studies have paid sufficient attention to the horizontal spatial expansion component of African towns and cities; yet this process portends significant policy implications for sustainable urbanization in terms of ecological efficiency for the natural environment, socio-political and economic intergenerational equity for the peri-urban community livelihoods (Parnell and Walawege 2011; Sebego and Gwebu 2013; Areola et al. 2014; Bo Haung 2009; Bryant et al. 1982). This paper therefore attempts to complement those studies that underpin urban sustainability in sub-Saharan Africa.

The city and countryside are integral parts of the same social and economic system. Therefore, the changes in the city and countryside are interdependent (Bryant et al. 1982). The rural areas around cities have however been increasingly placed under pressure as they have progressively become integrated into a particular form of settlement organization, characteristic of the Post-industrial Age-the city region (Meligrana 2003). The evolution of this broad functional organization of economic, social and, lately, even political space, has multiplied the demands placed on land and its resources, by creating conflicts and stresses, and has stimulated various adaptations of human activities (Ibid). Most cities are expanding in all directions resulting in large-scale urban sprawl and changes in adjacent land-use. The spatial pattern of such changes is clearly noticed on the urban fringes or city peripheral rural areas (Manoj et al. 2010). In developing countries, rapid peri-urbanization and increasing land-use changes, due to population and economic growth in fringe landscapes, is very apparent.

In Africa, peri-urbanization is driven, to a much greater extent, either by rural migration or hyper-urbanization, stemming from push factors such as landlessness, agricultural unemployment, resettlement, and insecurity in some rural areas (Muller, n.d.). The extent of the peri-urban land problem is not uniform but varies from city to city and from country to country. A pertinent question to ask is: Why and how did the peri-urban land-use problems develop in the first place and why do they continue to exist? Some of the reasons for the existence of the peri-urban land problems can be attributed to: (1) the massive rural-to-urban migration exceeding the management capacity of local rural and municipal authorities (2) the misconception associated with customary land tenure; and (3) the extension of ill-adapted land administration systems into the peri-urban environments.

The paper is organized into five sections. After this introduction, the next paragraph outlines the conceptual frameworks underpinning the study. Then, the methods and techniques used to collect and process the data and information are discussed, followed by analysis and discussion of the findings, then finally the conclusion and policy recommendations.

The conceptual frameworks

The study relies on three conceptual frameworks, namely, a combination of the rent bid model and the bow wave analogy and the stimulus–response idea.

Figure 1 combines the bid rent and bow principles, respectively. The bid price curve model, also known as the bid rent curve principle, is a general economic theory of urban land markets and location. It owes its existence to von Thunen's land use theory (von Thunen 1966). His model was developed to analyze agricultural land use patterns to explain the location of agricultural land uses outside an adjacent urban market. The theory is based on the assumption of the existence of a featureless plain upon which sits an urban center. The assumption is that, in a free market situation, the different competing land uses in and around an urban center, will make trade-offs between

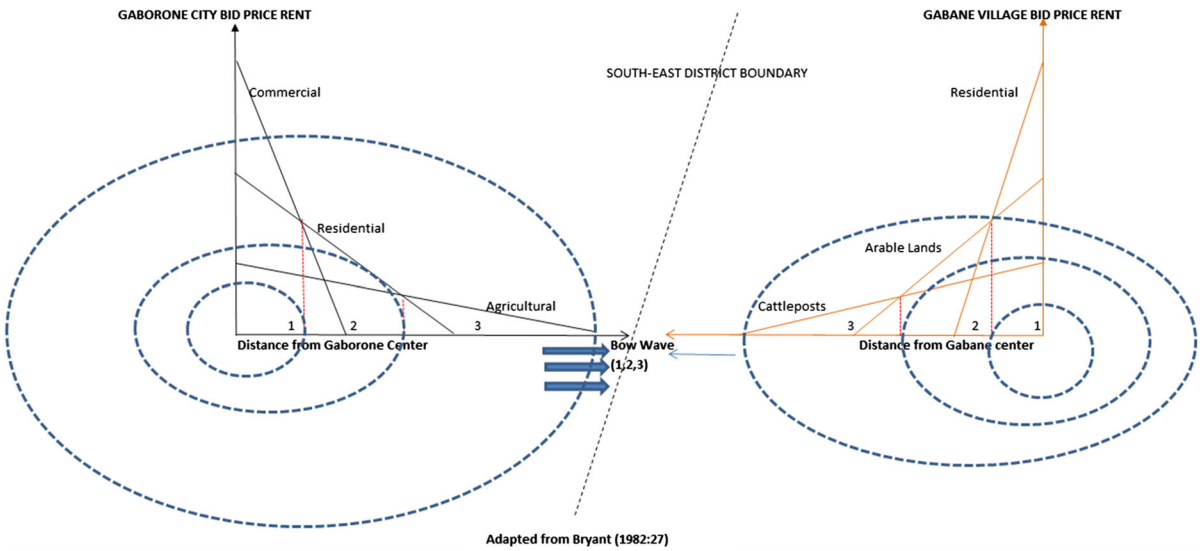

Fig. 1 The bid rent and bow wave concepts. *Source*: Authors 2013

land price, transportation costs, and the amount of land they occupy.

Land uses with the highest comparative economic advantage outbid the others and will therefore tend to be located nearer to the city center. Land uses with lower comparative advantages will then be relegated towards the periphery of the city, on the basis of their respective locational rents. This arrangement results in a concentric land use spatial structure, reflecting zones of land use in terms of their bid price curves, where land uses with the highest bid prices are located nearer to the city and those with lowest bid prices located far away from the city center.

The land use that derives the highest economic rent, assumes the dominance of use of that land. From that perspective, urban uses succeed and dominate rural land uses by virtue of their higher rent values. The bid rent curve model is therefore relevant to explain land use changes taking place around Gaborone. This comes amid reports of the rampant sale of farmland in peri-urban areas of Botswana, evidenced by events that have been taking place in Mogoditshane (Government of the Republic of Botswana 1992), a pattern that resembles those in many other peri-urban areas in Africa (Wily 2001).

A bow-wave as a standing wave that always remains in front of the bow of a ship, moving through water (Hart 1991). When applying the same concept to the growth of an urban area, urban land uses appear to be steadily displacing the rural ones at the urban–rural fringe, as the bow-wave of the built-up city or urban area appears to do. The rural–urban fringe is, normally, characterized by intensive cultivation and high-priced agricultural land. According to Hart, over the years the urban–rural fringe zone/bow-wave pushes outward as the city grows. In the process, agricultural activities are pushed farther out to a new outer fringe.

In applying the same analogy to peri-urbanization in Gabane, it can be argued that the urban–rural fringe zone of Gaborone is under intense pressure from the urban developments that are taking place in the city. This is an area which is characterized by low density development that was previously set aside for arable and pastoral farming. Due to the proximity of the area to the urban expanding built-up area, the land in the urban fringe is expected to acquire additional value, and, in the process, attract investments from land speculators, investors and the government. As a result, the rural–urban fringe of Gaborone has moved outward leading to conflicts, displacement and dispossession of the original tribal land owners (Government of the Republic of Botswana 1992). This scenario is attested to by the outward shift of the Gaborone boundary from time to time which now incorporates land previously set aside for agricultural purposes. Therefore, this study intends to investigate the process of peri-urbanization taking place in this zone to establish how it has affected land owners.

This study also uses the stimulus–response framework to examine the patterns and implications of land-

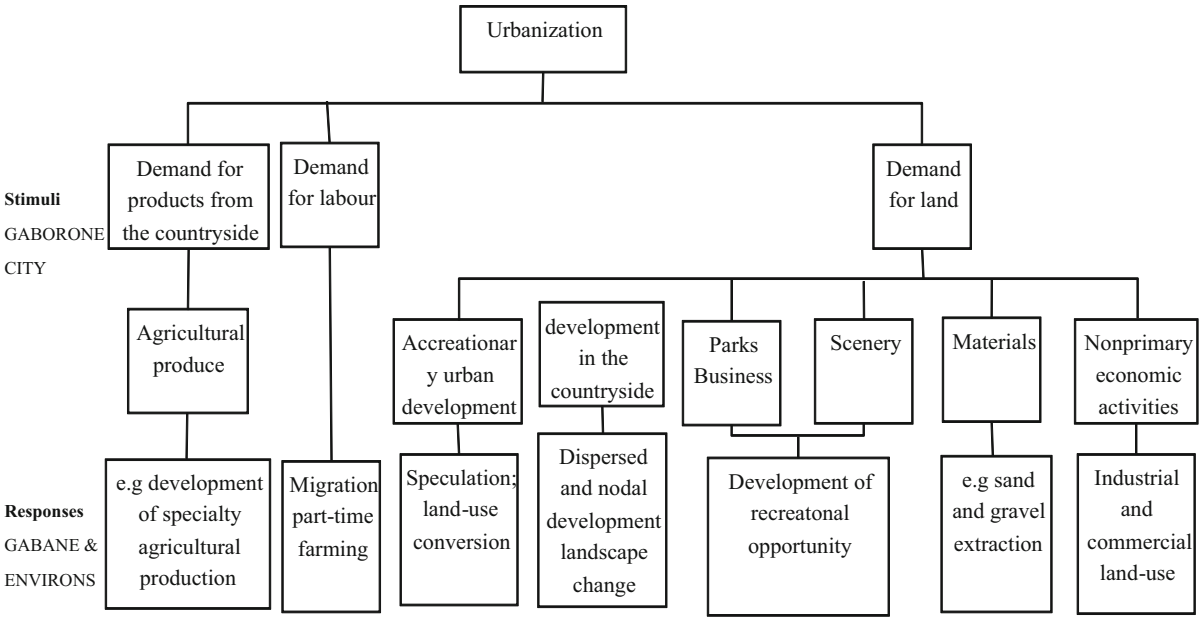

Fig. 2 Stimulus-response conceptual framework. *Source*: Adapted from Bryant, Russwurm and McLellan (1982)

use changes in Gabane village and its environs over time. Figure 2 depicts the stimulus–response components of the research problem and how they interact in the study area. The focus is on Gabane Village because it is located in close proximity to Gaborone City, a major urban area in Botswana. Therefore, the diverse emerging and expanding urban activities should impose pressure on the Village in the form of urban demand for the land resource. It is in this context that the stimulus–response model is applied to assess drivers of the land-use competition and change in the Village and its environs.

The stimulus in this case is prompted by the urban core of Gaborone with its various types of demands shown. The stimuli take the form of demand for agricultural products, labor and land from Gaborone. The responses take the form of satisfying the demands from the Gaborone city in various ways, from the periphery. This conceptualization assists this study to assess the extent to which Gaborone acts as a core and the range and magnitude of demands that it exerts on Gabane Village and its environs.

The study area

The peri-urban settlement of Gabane, as shown in Fig. 3, is located within the Kweneng district in the west of the capital city of Gaborone. It is located 15 km west of Gaborone, the capital of Botswana. The Village of Gabane covers an area size of 202.8 square meters (Report of Survey 2003).

Gabane is a foothill settlement that stretches from north to south with its eastern side lying between Mogoditshane and Kumakwane villages, along the Gaborone-Kanye road. The location of the settlement and its localities of Mmokolodi and Tloaneng accords it a great potential for transforming into a thriving satellite of Gaborone city. The Village is already showing prospects of becoming a main dormitory settlement, taking advantage of the saturation of Mogoditshane in the future.

Located on "loaned Batlokwa tribal land" and surrounded by a number of freehold farms, Gaborone has been constrained in its horizontal growth. It has had to subsequently encroach on the surrounding villages of Tlokweng and Mogoditshane, generating controversy between communal tribal land and freehold municipal tenure systems (Nkambwe and Totolo 2005; Nkambwe 2003). Because of the seriousness of these conflicts, the Government of Botswana has instituted several commissions of enquiry in order to resolve the disputes arising from encroachment of urban uses on tribal land.

Figure 4 shows the population growth trends of Gabane over the last five decades. In 1971, the village

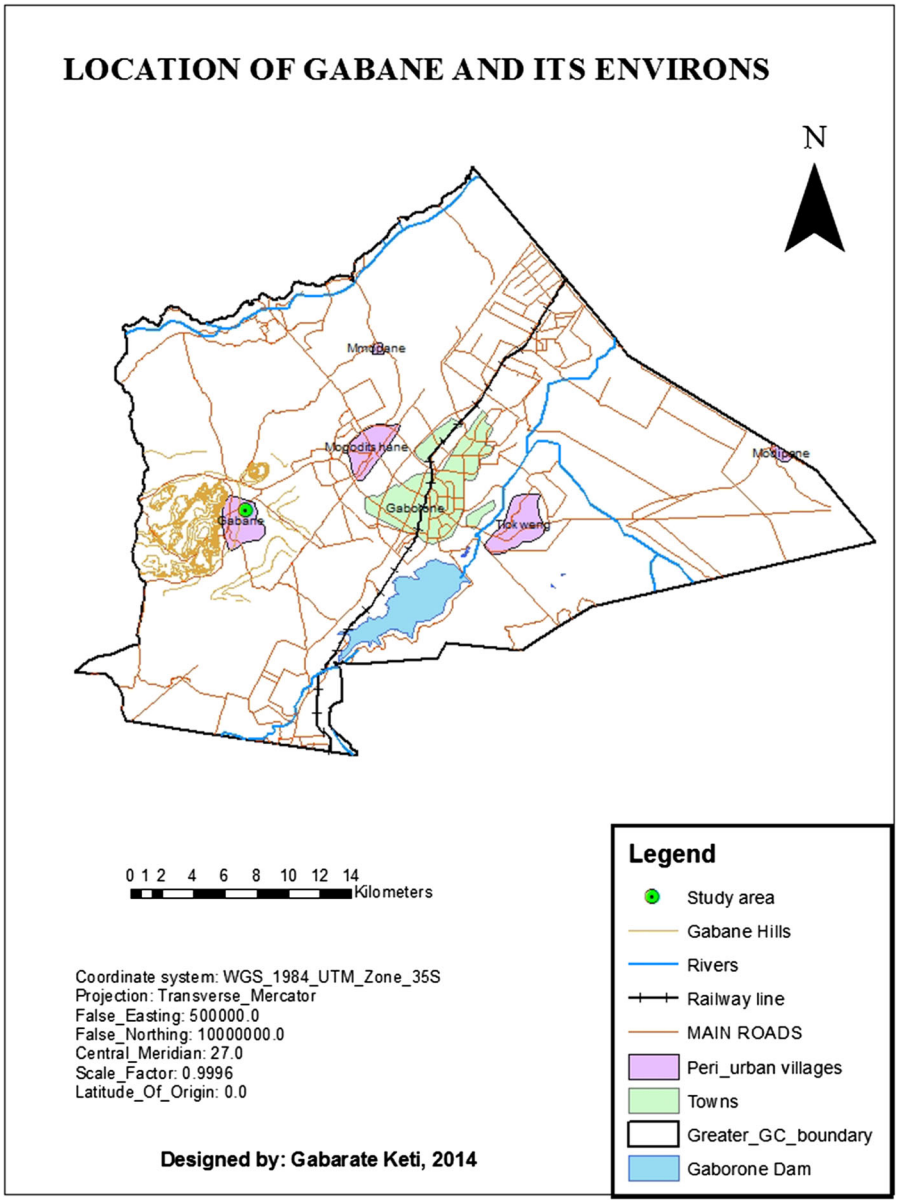

Fig. 3 Location map for Gabane Village in relation to Gaborone. *Source*: (Keti 2015)

had a population of 1963 and by 1981 the population had grown to 2688 showing a growth rate of 3.2% during the period.

By 1991, the settlement's population had grown to 5975 persons. During the intercensal period 1981-1991, the growth rate was 8.3%. The year 2001 revealed that 10 399 people resided in Gabane, revealing a growth rate of 5.7% while the recent census in 2011 showed a population of 15,237, making it the fourth largest settlement in Kweneng District. It is now part of the Gaborone urban agglomeration that was home to 421,907 inhabitants at the 2011 census. The elderly population of the Village is still very much into subsistence agriculture while the younger more urbanized residents tend to prefer formal sector employment.

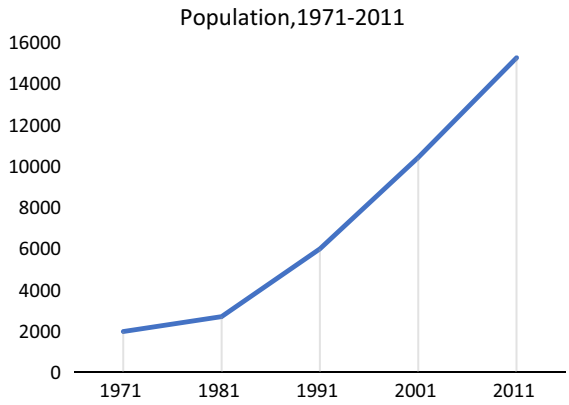

Fig. 4 Population growth of Gabane. *Source*: Statistics Botswana (2011)

Materials and methods

In order to enhance the validity of its findings, the study drew on board the triangulation research method.

Data and data sources

The specific techniques applied include; Geographic Information Systems (GIS), social survey and the historical landscape reconstruction. GIS was used to process aerial photos and satellite images of 1982, 1996, 2006 and 2013 to exhibit the trends in land-use change patterns (Vizzari 2012), in Gabane Village. Aerial photos of 1:50 000 were obtained from the local Department of Surveys and Mapping. ARCGIS was used for the handling and processing of aerial photos and satellite images. Aerial photos were scanned and georeferenced to the UTM coordinate system. This enabled the mosaicking of the aerial photos and thus, the reconstruction of the Gabane Village landscape overtime. Additional spatial data were obtained from the Department of Town and Regional Planning. This enabled the analysis of possible future land-use trends in the study area and their possible implications for the population dynamics in the urban fringe. The above processes resulted in the creation of land-use trend maps, land-use conflict maps, biodiversity trend maps and projected land-use trend maps.

The GIS methods were augmented by a social survey that was conducted on the residents in the study area. The social survey allowed for the performance of trend analysis on how peri-urbanization had affected the livelihoods of a cross section of the residents of Gabane. For this purpose, a space–time stratification of the village residents was done. Space was based on the older and newer sections of the settlement. Time was based on the length of the respondents' residency in Gabane Village. Relevant data sought included: biodata, residency status, personal and communal livelihood assets (types, quantities, access, opportunities), changes in access to assets over time, drivers to changes in assets over time, outcomes from changes over time, threats to livelihoods, opportunities to enhance livelihoods, infrastructure development over time, and, service provision over time.

Sampling for the social survey was based on data from the 2011 Housing and Population Census. The Yamane formula based on 90% confidence level and 10% sampling error allowed for 96 households to be selected for detailed interviews from a total of 3 452 households. Random sampling was employed to select respondents to the household questionnaire. Additionally, the Historical Landscape Reconstruction (HLR) method was utilized for collecting data from purposively-selected sources. HLR is a way in which human memory can be mined for data concerning the environments in which people lived in the past, and in which they are living at the present moment (Maphanyane 2012:99). Therefore the data becomes pliable and can, consequently, be analysed, differentiated, subtracted and merged. HLR data and information were obtained from the Village Chief, purposively- selected elderly, the Department of Town and Regional Planning, the Ministry of Agriculture the Kweneng Land Board, and the National Archives. This provided the earliest descriptions of the settlement including the rationale for its siting, its original functions, rudimentary mapping, the contemporary descriptions of the settlement and its development in relation to Gaborone, land use, land use changes, competition and conflicts as well as the resolutions that have occurred as a result of peri-urbanization.

Data processing

ARCGIS was used for handling, processing and analysing aerial photos and satellite images. Various Arcmap functions such as intersects, co-location, classification, and calculate were applied during aerial photo and satellite image processing in order to derive quantitative data. Such figures were used for the

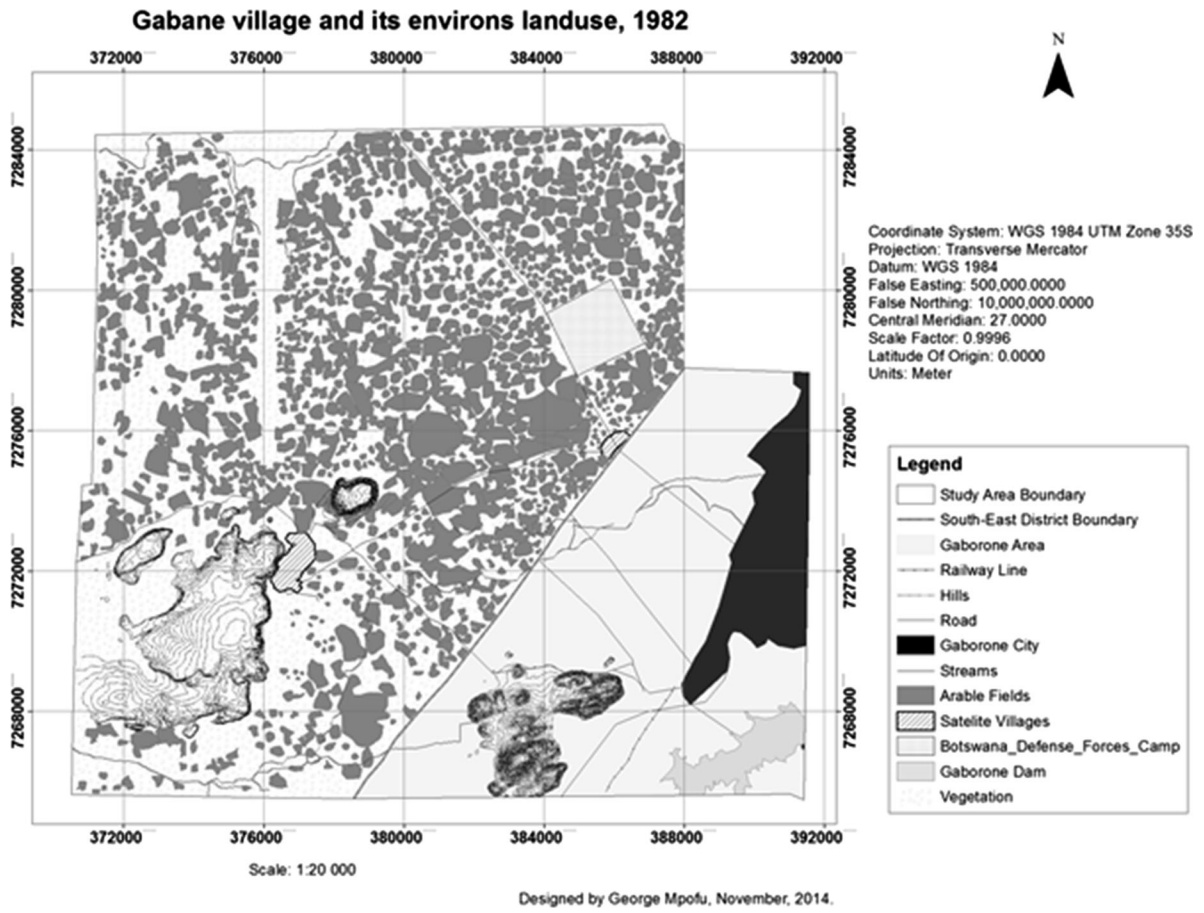

Fig. 5 Gabane Village and its environs land-use and land cover 1982. *Source*: Department of Surveys and Mapping 1982

analysis of land-use trends and changes in the study area.

Data editing, cleaning, coding, entry and processing were performed to facilitate data analysis and interpretation. The Statistical Package for Social Sciences (SPSS) software was used to handle, manipulate and process quantitative data from the social survey.

Thematic analysis was adopted to facilitate analysis of qualitative data from the historical landscape reconstruction exercise. Sub-themes were constructed to enable thematic analysis.

Results

Measurements of land cover and land use for 1982 are shown in Fig. 5. They were obtained through the application of GIS.

Figure 5 shows that there was no significant economic activity or infrastructure in competition with the arable activity, except for few lines of roads meandering about Village boundaries. The roads served the purpose of interaction between Gabane Village and Mogoditshane Village-the only other rural settlement existing in the vicinity of the former at the time.

Gabane Village was a typical rural area, characterized by a predominantly agricultural landscape, consisting of arable land-use and natural vegetation land cover-hosting biodiversity. The villagers grew crops and reared livestock for subsistence as the financial potential of arable activity was not tapped into at that time (Mmipi 2000).

This section analyses evolving land-use trends in Gabane Village that are associated with peri-urbanization since 1982. Based on the 1982 aerial photos,

the spatial extent of arable land with active ploughing fields measured about 107 hectares and the biodiversity area measured 53 hectares. Gabane and Mogoditshane villages jointly measured about 23 hectares, highlighting their small population at that time. The large tracks of land available for ploughing and biodiversity facilitated thriving rural livelihood activities with no discernible outside or urban influence being directly or indirectly exerted on Gabane village and its environs. The general land-use in Gabane village and its environs in 1982 mirrored what was generally experienced in the Sub-Sahara African space economies, that is, their duality in nature as revealed in literature (Gwebu 2004). According to Gwebu, the modern sector economies concentrated in the metropolitan cities while the traditional activities were based in the rural areas. Within this dichotomous setting, urbanization was still a phenomenon yet to be experienced. The rural agrarian economy was a sustainable source of livelihood as urban influences were yet to be experienced in these Villages.

Figure 6 depicts the land-use changes that occurred between 1982 and 1996 in the study area.

The figure shows a significant transformation of the original rural landscape due to its invasion by urban related functions.

The map evidence for the observed changes in land-use between 1982 and 1996 is shown in Table 1.

The period starting in 1996 could be conceived as the time that ushered in a mosaic of emerging land-uses, encroaching and displacing the traditional rural land-uses and the biodiversity that had existed in 1982. Road networks began to expand within the village including those major roads that linked the peri-urban villages to Gaborone city. The interaction between and within Village and its environs, and also with Gaborone city had grown significantly. The road network had displaced large tracks of arable fields and natural land cover through the consumption of 35.11 hectares of land. The picture painted by Gwebu (2004) of rural–urban linkages was beginning to emerge, judging from the level of interaction between Gabane and its environs and the city of Gaborone, gleaned from the expansion in construction of the road network.

The subsistence activity both in crop production and livestock keeping was beginning to be displaced (Ralph and William, 2001; Ikgopoleng et al. 2011). This can be gleaned from a number of fallow fields which have replaced the active arable land and the growth of the other land-uses in the former livestock grazing areas.

Other peri-urban settlements were also growing, signifying an increase in population around Gaborone. The residential areas in these settlements expanded at the expense of arable farming. Peri-urban villages such as Mmopane and Metsimotlhabe were starting to emerge on the map by the year 1996, in the former Gabane Village arable lands and livestock grazing areas. The residential area had grown from 23 hectares in 1982 to about 33.15 hectares by the year 1996, indicating a remarkable growth by 45.7%, as shown in Table 1. These findings contradict those of Cavric and Keiner (2004) who claimed that there was some depopulation of rural–urban fringe. Instead, there was growth of the residential areas paralleled by a growing population in Gabane Village and its environs due to urbanization pressure from Gaborone.

What the maps from this study resonate with, in Cavric and Keiner's study, is that there was a general and gradual decline in agriculture and the deterioration of the natural land cover as well as uncontrolled rural urbanization in the fringe zones of Gaborone. Several fields that had been used for crop production in Gabane Village and its environs in 1982 were lying fallow in 1996. The arable land-use had been reduced from 107 hectares in 1982 to 50 hectares in 1996, indicating a negative growth of 53%. On the other hand, vegetation land cover declined by 76% from 53 hectares in 1982 to 13 hectares in 1996, implying a considerable decline in biodiversity.

The influences of growth of the Gaborone city were also beginning to be noticed, as activities that supported its growth were manifesting themselves in Gabane Village and its environs. For example, the harvesting of aggregate mineral resources such as sand, gravel, and quarrying meant for construction in Gaborone City were beginning to leave their footprints on traditional arable landscape and biodiversity. The relics of these activities include burrow pits all over the peri-urban villages of Gaborone as confirmed by Geoflux (1994). Certain very large borrow-pits were found to have encroached or displaced the ploughing fields and natural landscapes altogether. See Fig. 7.

The burrow-pits that emerged on the peri-urban landscape by 1996 confirmed that the peri-urban land was not being used on the basis of its capability and suitability (Cavric and Keiner 2004). Once degraded

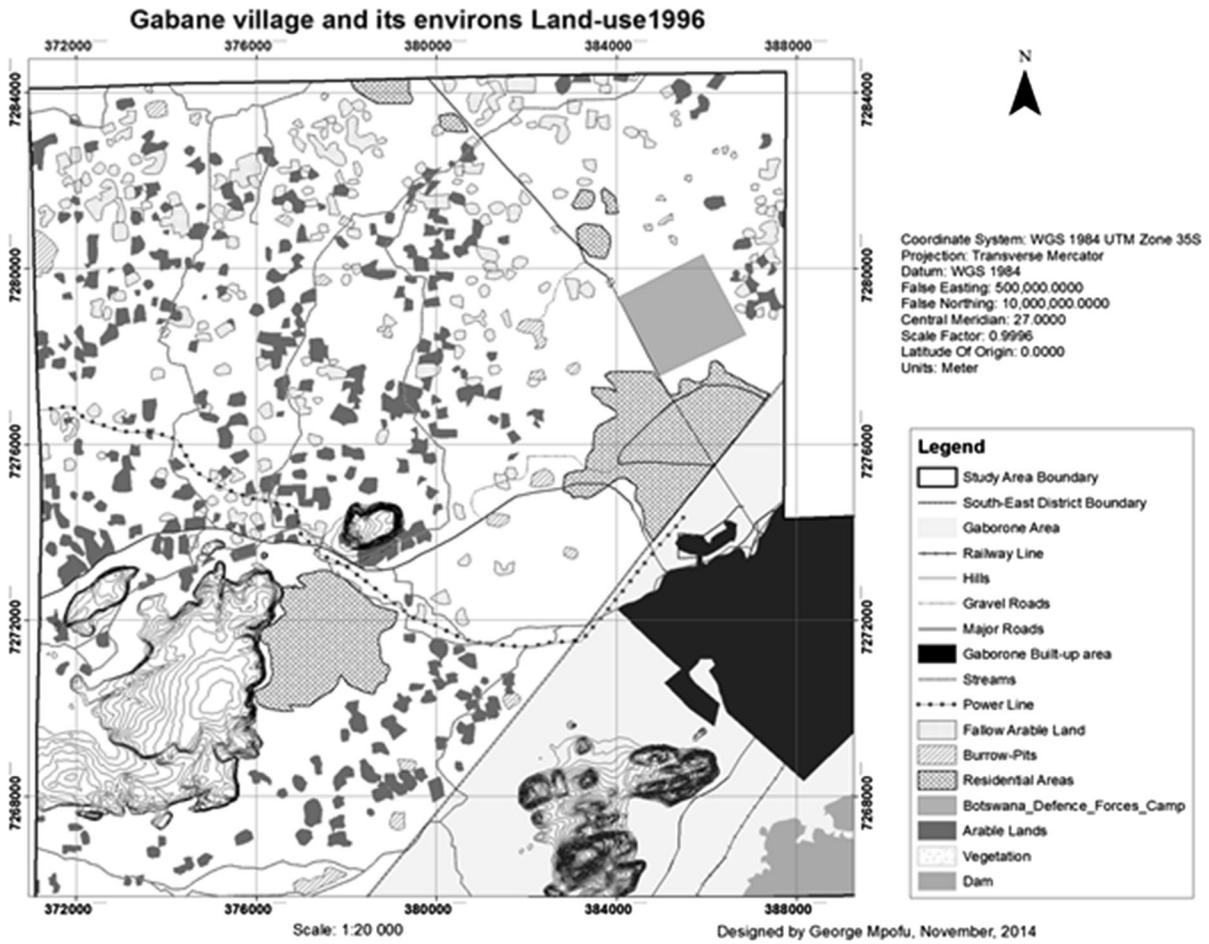

Fig. 6 Gabane Village and its environs land-use disposition in 1996. *Source*: Landsat Image 1996

Table 1 Land-uses and land cover change 1982–1996. *Source*: Landsat Image 1982 Aerial photos and 1996 Greater Gaborone

Land-use/Land cover type	Size (hectares) in 1982	Size (hectares) in 1996	% of change
Arable land	107	50	−53.28
Fallow fields	0	11.2	0
Residential areas	23	33.15	45.71
Electrical power lines	0	13.1	0
Major roads	0	35.11	0
Illegal dumpsites	0	14.12	0
Burrow pits	0	13	0
Vegetation	53	13	−76.05

and converted into burrow pits, the land would then be derelict as it became unsuitable for both arable and urban uses.

The installation of an electrical power line that formed a grid supplying Jwaneng Diamond mine, created a 13.1 hectares buffer. This buffer dissected a number of arable fields and natural land cover, leading to the loss of arable land and biodiversity. Gaborone City too, had been growing, in physical terms, and had begun to exert additional pressure on its peri-urban rural settlements. The increase in the number and intensity of land-uses experienced in Gabane Village

Fig. 7 Burrow-pit in the crop field in Gabane Village. *Source*: Author

and its environs appear to have been related to the growth of Gaborone City. Some of these emerging land-uses existed mainly to support the varying needs of Gaborone City rather than the peripheral settlements, for example, the burrow-pits due to the aggregate mineral demand for construction activities that were taking place in Gaborone City.

Gabane Village and its environs displayed a significant change in land-use since 1982, and this was consistent with the claim that the fringes of urban areas are always subject to rapid change (Blacksell and Gilg 1981). They, as zones of transition from urban to rural land-uses, continued to experience change, in spite of Development Control requirements of the Botswana Settlement Policy and the sanction of Green Belt designation, which had been adopted worldwide, following its initial success around London in the post-war era (Silitshena 1996; Clancy 2008; Lovett 2008).

Figure 8 captures the changes that occurred between 1996 and 2006. It shows the continuation rapidly expanding urban uses and diminishing rural land-use.

The land-use change numerical trends are shown in Table 2.

Table 2 shows a comparative profile of land-use changes in Gabane village and its surroundings between 1996 and 2006. It shows that urban-related land-uses had continued to expand since 1996. Population increase in Gabane village and its environs had seen the expansion in the area occupied by the residential uses. Residential area cover increased to 50 hectares from 33.15 hectares in year 1996, signifying a 50.8% growth. There had been a continued growth of Gabane Village and its environs, and for the first time, Metsimotlhabe Village became evident on the map.

The whole rural area now fell within the Planning Area of Gaborone city. The Village and its environs had come under the jurisdiction of the Town and Country Planning Act that required compliance with municipal physical planning regulations. This further exerted pressure on the arable land-use and biodiversity of Gabane Village and its environs. This was evidenced by the land set aside for residential area development in the north-western part of the Sir Seretse Khama army Barracks. The planned residential area measured about 3 hectares, and constituted part of what had formerly comprised arable fields and the natural land cover in 1982.

The construction industry had experienced a boom in Gaborone city (Mpofu 2010), and resulted in the generation of waste and its illegal disposition on the open spaces in Gabane Village and its environs (Ikgopoleng et al. 2011). Evidence of this development were the illegal dumpsites, shown in Fig. 8, which consumed a total land area of 11.25 hectares of the arable land and natural vegetation. The vegetation land cover had been very important to the residents on the urban fringe, since it served the dual purpose of livestock grazing, and as a source of veld products and fuel energy.

The land was also being used for the additional construction of a number of internal roads in the peri-urban fringe. Through observation, it became evident that the gravel roads were used as access roads to illegal dumpsites and also the burrow-pits. Burrow-pits shrunk both in size and numbers in 2006, now measuring 13 hectares as compared with 15 hectares in 1996. Their decline of 17.65% was facilitated by their reclamation and rehabilitation in response to an increase in demand for urban residential use. The expansion in demand for residential use had been prompted by the rural–urban migration between Gaborone and the other rural settlements.

Gaborone City had expanded in population size and registered an outward growth toward its peri-urban settlements. This growth has been responsible for an increase in the number and the emergence of new land-uses that have encroached into Gabane Village and its environs. For example, Fig. 9 shows the spatial land-use patterns for 2012, while providing a basis for the derivation of land-use figures tabulated in Table 3.

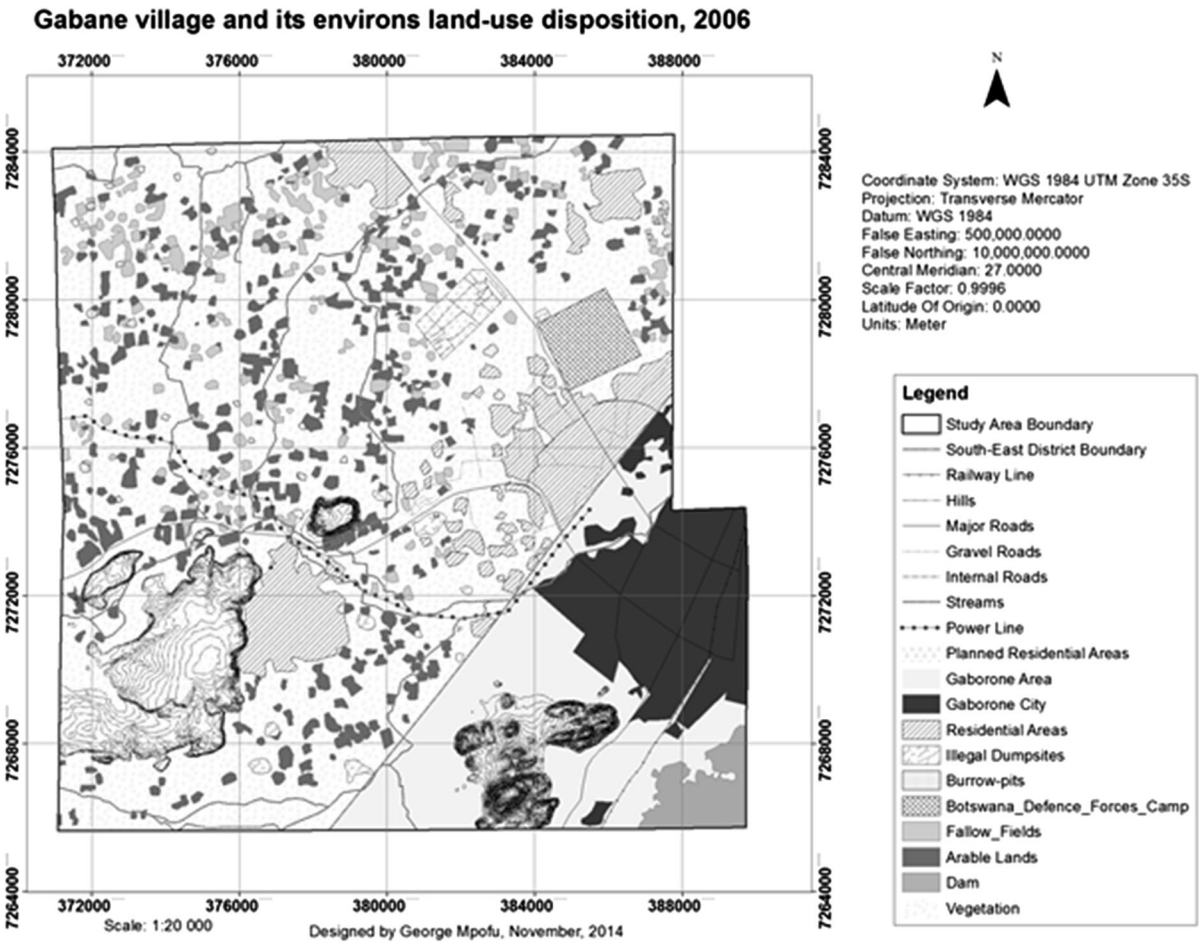

Fig. 8 Gabane Village and its environs land-use scenario in 2006. *Source*: Google Earth Image 2006

Table 2 Comparative analysis of land-use scenarios of the period 1996–2006. *Source*: Landsat Image and 2006 Google Image 1996 Greater Gaborone

Land-use/Land cover type	Size (hectares) in 1996	Size (hectares) in 2006	% of change
Arable land	50	31	−38.14
Fallow fields	11.2	14.33	27.95
Residential areas	33.15	50	50.83
Planned residential areas	0	3	0
Electrical power lines	13.1	13.1	0
Major roads	35.11	36.00	2.53
Illegal dumpsites	13.12	11.25	−14.25
Burrow pits	15	13	−13.33
Vegetation	12	11	−8.33

The Table shows an intensive development of urban land-uses between 2006 and 2012, in the form of sand-mining, industrial activity, infrastructure and other important functions that were responsible for declining rural land-uses of arable and grazing practices.

By the year 2012, there had been land zoned for future industrial expansion and Planned Industries estimated to cover about one hectare. Also, a total of 6 hectares of the former arable land-use had been converted to Active Industries. The mining of

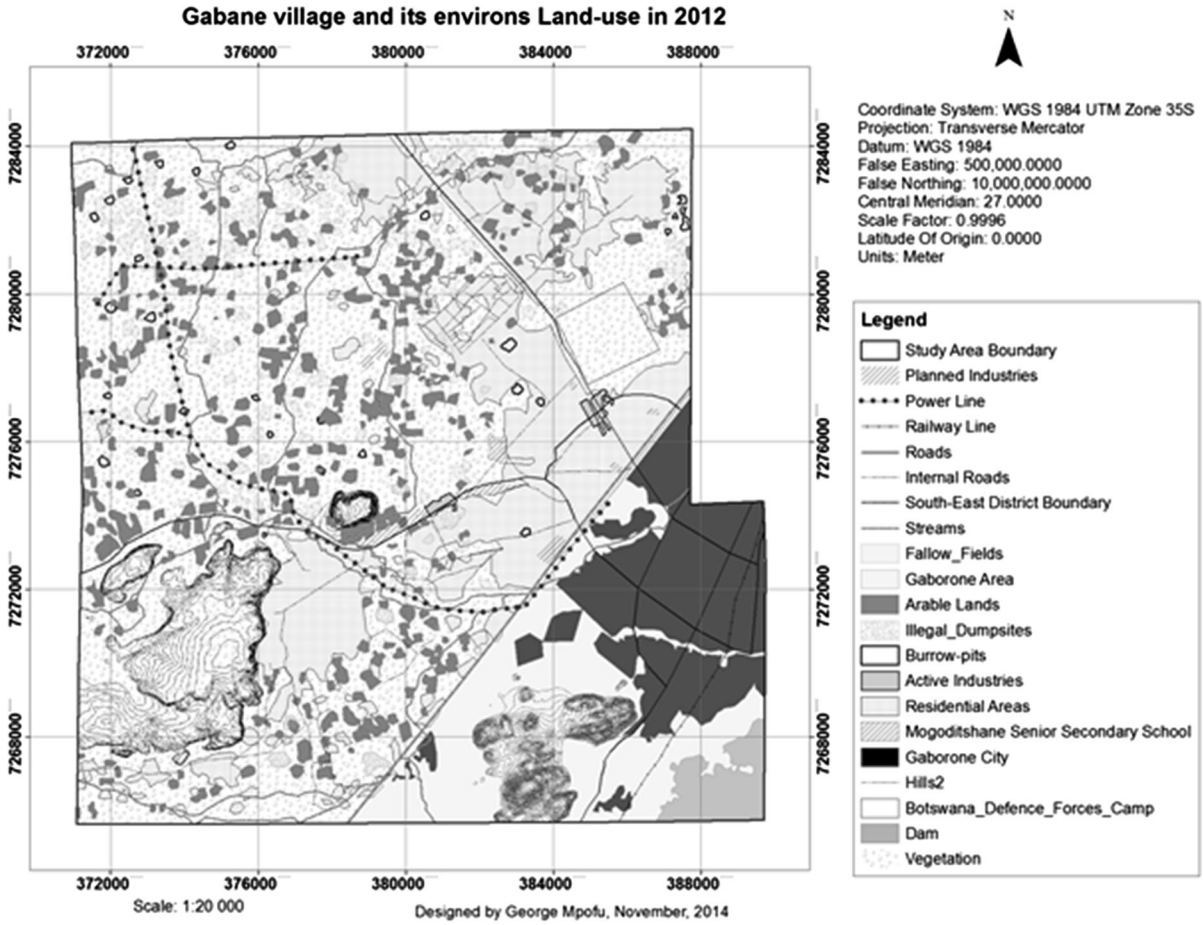

Fig. 9 Land-use 2012 in Gabane Village and its environs. *Source*: Google Earth Image 2013

Table 3 Land-use trends for the 2006–2012 period. *Source*: Google Earth Image 2006 and 2012

Land-use/Land cover type	Size (hectares) in 2006	Size (hectares) in 2012	% of change
Arable land	31	15	−51.61
Fallow fields	14.33	5	−65.1
Residential areas	50	73.00	46
Planned residential areas	3	6	0
Active Industries	0	6	0
Planned industries	0	1	0
Electrical power lines	13.1	13.1	0
Major roads	36.00	37.00	2.7
Illegal dumpsites	11.25	4	−64.44
Burrow pits	13	16	23.38
Vegetation	10	7	−30

Fig. 10 Sand harvesting in the Metsimotlhabe river channel. *Source*: Author's Field Work 2013

aggregate minerals such as sand and gravel, shown in Fig. 10, was also expanding.

The number of burrow-pits, indicative of construction aggregate mining activity, increased to 16 hectares 2012 from 15 hectares in 2006, a growth of 23.38%, as shown in Table 3. The increase in sand and aggregate mining was linked to the growth of Gabane village and its environs and Gaborone city.

The built-up areas had visibly expanded and by 2012, the residential areas in Gabane village and its environs consumed a total of 73 hectares of the former arable land and the natural land cover. The growth of residential areas had been coupled with a parallel increase in the number of roads within the study area. The buffer created for road networks consumed about 37 hectares of land that had constituted arable land and biodiversity in 1982.

In 2012, the land-use map shows a marked decrease in the total land under arable activity from 31 hectares in 2006 to 15 hectares. This decrease was coupled by yet another 65% decrease in fallow fields which now measured about 5 hectares instead of 14.33 hectares in 2006. The decline in fallow fields and arable land was associated with the growth in the built-up areas comprising of residential areas, active industries, planned industries, burrow-pits and road construction. Illegal dumpsites had been rehabilitated and declined to 4 hectares, from 14.2 hectares in 2006. The vegetation cover had seen a decline from 10 hectares in 2006 to 7 hectares in 2012, representing about 30% of negative growth. The reduction in arable land and vegetation cover signified a decline in arable land-uses and the depletion of biodiversity in Gabane Village and its environs. These were mainly displaced by the encroaching urban land-uses that grew and expanded at their expense.

A summary of land use trends 1982–2013

Table 4 shows landuse trends from 1982 to 2013 in Gabane village and its environs.

From Table 4, it is evident that in the year 1982, most of the land-uses did not exist except for arable land-use, vegetation cover and residential areas. The residential land-use had insignificant spatial coverage. Most of the urban-related land-uses emerged by the year 1996, and consumed a combined a total of 121 hectares of arable land and the vegetation cover. This area had rapidly increased to 138 hectares in 2006 owing to urbanization pressure from the city of Gaborone. By the year 2012, planned residential areas, active industries and planned industries had emerged as new urban-related land-uses encroaching into arable lands and biodiversity areas. With the exponential growth associated with these and other urban-related land-uses, a total land area of 143 hectares in year 2012 had resulted in the decline of the arable land and vegetation cover. The village and its surroundings presented a complex picture of landscape comprising of a mosaic of rural and urban-related land-uses providing the likelihood of conflicts among the diverse and competing land-uses.

Looking into the future

Figure 11 is a Future Development Plan map of Gabane Village and its environs that suggests areas for potential future land-use competition and potential biodiversity loss areas.

The revised study area boundary was suggested by the Department of Town and Regional Planning to effectively include all the administrative localities of Gabane Village and its environs. The anticipated upward growth for all the urban-induced land-use types implies a negative growth in the arable land-use and a decline in areas under biodiversity.

It could be thus deduced from the land-use development plan that arable agriculture and open vegetation will not be considered a priority by the development planning authorities. The built-up environment consisting of proposed residential neighborhoods and

Table 4 Summary of land-use trends for the period 1982–2013. *Source*: Author's field work 2013

Land-use/Landcover	Hectares 1982	Hectares 1996	Hectares 2006	Hectares 2012
Arable	107	50	35	31.08
Fallow fields	–	11.2	14.33	11
Vegetation	53	12	10	8.03
Residential	23	33.15	65.42	95.34
Planned residential	–	–	–	2.32
Active industrial	–	–	–	13.23
Planned industrial	–	–	–	45
Electrical powerlines	–	13.1	13.1	13.1
Major roads	–	35.11	39.03	57.13
Illegal dumpsites	–	14.12	11	9.12
Burrow pits	–	13	15	16.4

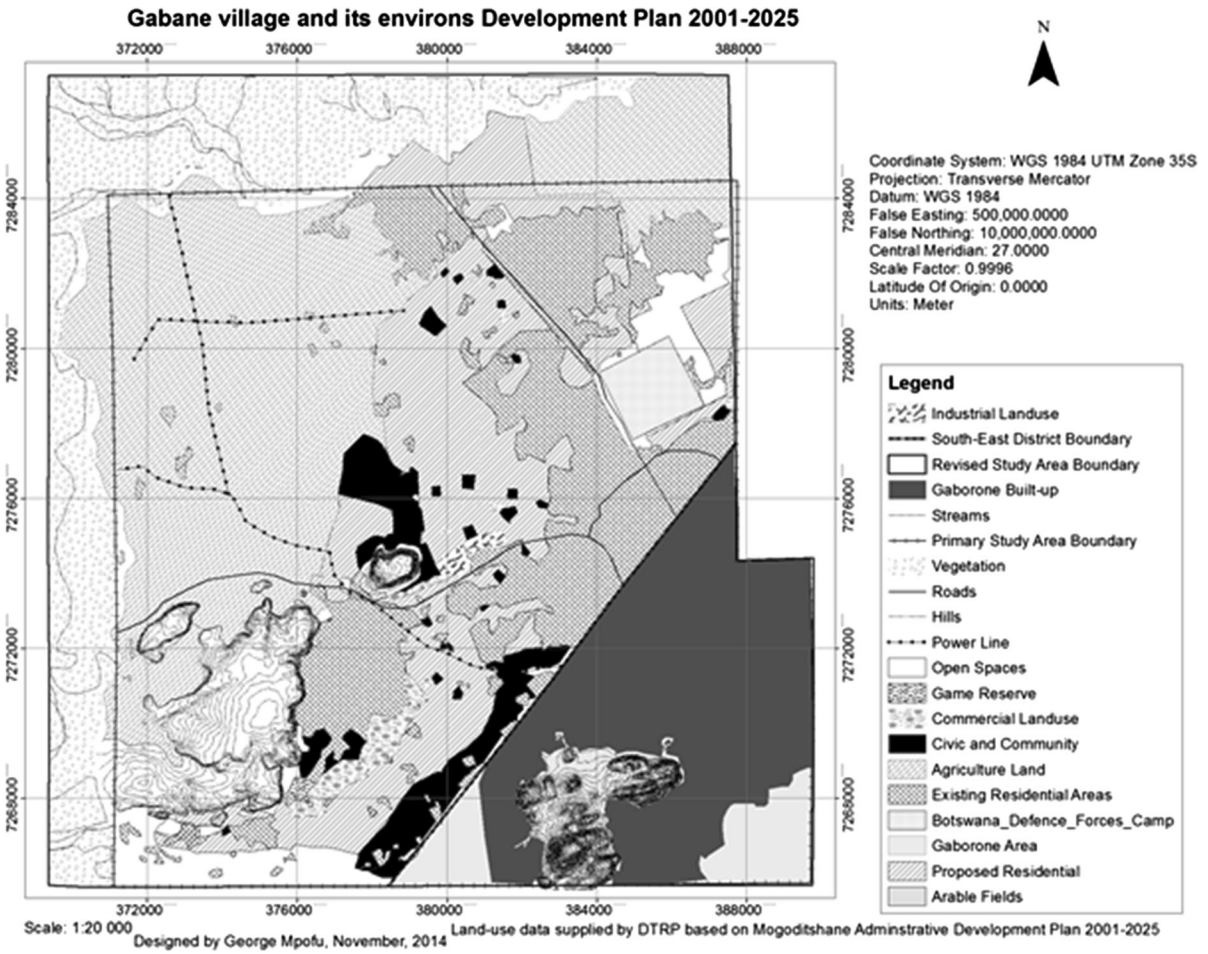

Fig. 11 Gabane Village and its environs Development Plan Period 2001–2025. *Source*: Department of Town and Regional Planning 2015

community and civil centers will translate into a massive spatial growth. This may be indicative that the planning authorities foresee marked growth in population that will require the reservation of a larger chunk of land to accommodate the increasing urban demand for residential related activities. The map also shows the anticipated massive growth in civic and community, commercial, and industrial land-uses.

A relative small area is reserved for the conservation of wildlife resources through the creation of a game reserve. There will be expansion in the electricity power line infrastructure, thus, a lot of arable land will be consumed by urban uses in the process. Only small quantities of land are set aside for agriculture. Such agricultural activity is appropriately referred to as 'urban agriculture'.

A number of projects were being carried out in Gabane Village and its environs. These fell under urban agriculture, such as goat and poultry farming, horticulture as well as piggery projects. However, few peri-urban residents, if any, partook in urban agriculture mainly due to the high initial and operational capital required for the projects. It is therefore safe to assume that urban related land-use will continue to compete and conflict with arable farming activities and biodiversity therefore pose a threat to peri-urban residents' livelihoods. The Plan provides a rare-insight into the impending cut-throat land-use competition and conflicts that inevitably would result in possible peri-urban arable livelihood activities ceasing to exist altogether, with untold economic implications to those that depend on it (Wily 2001).

Conclusions and recommendations

Findings

This study set out to determine the land-use changes and competition in and around Gabane area, establish their causes and effects since 1982. In order to achieve the stated aim, the study used GIS techniques, and historical landscape reconstruction. The results have been presented both in maps, tabular and graphic forms as well as in description and analysis. Through the GIS mapping techniques, the study established that indeed there had been extensive land-use changes and biodiversity loss since 1982.

While in 1982 there had been a predominant arable land-use and natural land cover, the progress over the years had seen an encroachment into Gabane village and its environs of urban-type land-use activities. These had grown significantly and by the year 2013, the arable land-use and biodiversity had seen a massive decline and their economic significance became negligible. Evidence of change in land-use and loss of biodiversity has been widely documented and mapped out in the analysis section of this study.

A combination of historical events, socio-political and economic factors highlight and explain the present location and direction of growth of Gabane Village and land-use challenges experienced. Distinct land-use transition periods were identified in the socio-economic transition of Gabane Village and environs as they bear the brunt, firstly of urbanization pressure from Gaborone, and secondly, of the peri-urbanization pressure in their environs. Land-use, competition, conflicts and change in Gabane Village and its environs conformed to the basic tenets of the three conceptual frameworks that underlie the study.

Land-uses that command higher locational rents compete and displace those offering lower rents. The peri-metropolitan bow wave of Gaborone is moving outward, displacing rural land-uses in the process. The study demonstrated that Gabane Village and its environs or the immediate fringe at the edge of the city were the bow-wave of the built-up area of the city (the moving ship) that remained immediately in front of the expanding edge. In the process of the urban growth, this fringe was inundated, hence explaining the rationale for the land-use change and biodiversity loss. The influence of the city's bow-wave was so strong that it pushed back the inertia of the weaker Gabane Village. The process-state- response framework has also been verified in analysing the spatial dynamics that shape the evolving urban–rural interface at the study area. It has been proven that pressure in the form of demand for land and natural resources presented the stimuli by Gaborone city. Gabane Village and its environs served as the response areas, through meeting various needs by accommodating the urban activities and providing the resources for urban growth. The future Area Development Plan is set to ensure, through Urban Standards and urban Development Control Codes, the succession of rural land use by urban ones.

Recommendations

The following are recommendations that the study proposes to minimize the undesirable land-use trends and biodiversity loss that have been established in the study area. It has been noted by this study that Gaborone's growth was not properly planned from the onset. Due to its location on "loaned Batlokwa tribal land" and surrounded by a number of freehold farms, Gaborone was always bound to be limited in its horizontal growth. It had to eventually encroach on the surrounding villages of Tlokweng and Mogoditshane, generating controversy between communal tribal land and freehold municipal tenure systems (Nkambwe and Totolo 2005; Nkambwe 2003; GOB 1992). Individuals owning land under freehold land tenure have frustrated the government land acquisition efforts. Thus, the government has always turned to the communal land at the peripheries of the city to enable Gaborone to grow. The government should look into improving security of property rights of people that own land under the customary tenure through facilitating the process that would see such land owners attain legal documents such as title deeds. These would protect their property from arbitrary and compulsory land acquisitions. It would also ensure that poor peri-urban residents enjoyed the same legal entitlement that has for far too long been enjoyed by the rich freehold land owners around Gaborone city. There is need for a long-term strategy for urban development that rationalizes and promotes the optimal use of land and the preservation of the best arable land as well as conservation of natural resources for the benefit of present and future generations (Areola 2011). Given the inevitable encroachment into the neighboring agricultural farms and pristine ecosystems, during spatial expansion of the city, the Plan should provide guidance in conserving and harmonizing all land uses.

The Department of Town and Regional Planning (DTRP) should use the space optimally within the city of Gaborone to delay its horizontal or outward push. For example, there should be infilling of vacant lots, and, where feasible, vertical over horizontal expansion should be encouraged and promoted. The Physical Planning Department can borrow a leaf from the existing Human Settlements Policy and its concerns for environmental sustainability. The problem of environmental degradation should be viewed from both cognitive and legal aspects. Environmental policing should be established and environmental consciousness inculcated to prevent illegal sand and aggregate mining that had converted the once pristine Gabane Village lands and river bed along the Metsimotlhabe catchment area into burrow pits. Mining regulations should be enforced, and if they are found ineffective, be reviewed with the view to strengthen them to curb illegal aggregate mining. Finally, more attention needs to be paid to the social justice dimension of sustainable development in order to ensure the livelihoods of the rural residents of Gaborone's peri-urban settlements.

Compliance with ethical standards

Conflict of interest We the listed authors of the attached article have complied with the requires ethical standards demanded by this journal.

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