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Trends in Coastal Development and Land Cover Change: The Case of KwaZulu-Natal, South Africa

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Abstract—Current land cover and development in the coastal zone of KwaZulu-Natal (KZN) is assessed in this paper. It looks at historic changes in coastal development and land cover over time in two areas. The KZN coastal zone has and continues to undergo rapid development due to a number of causes, including population growth, social and economic development and climate-induced factors. The results indicate that a very high proportion of the KZN coastal zone is already densely developed, with much of this being unevenly distributed. It is argued that urgent management interventions are needed to ensure the long-term sustainability of the coast and the ecosystem services that it delivers, and to provide protection for the developments in the coastal zone. The new South African Integrated Coastal Management Act provides a framework within which this can be achieved.

INTRODUCTION

Globally, land use patterns are continually changing in response to human demands and needs (Houghton, 1994; Department of Environmental Affairs and Tourism (DEAT), 2006). These changes reflect our history, and to some degree our future, and are driven by a complex suite of factors including social and economic development, population growth, changes in technology (Houghton, 1994) and, increasingly, climate-induced factors. It follows that, in general, the type of land cover reflects underlying land use. Changes in land cover, primarily in the form of development, can be regarded as the single most important variable affecting ecosystems (Vitousek, 1994). In spite of this, there is little understanding of the dynamics and the significance of changes in land cover which have resulted in various forms of degradation of the natural environment (Gangai & Ramachandran, 2010). Inadequate data are available to assess the extent of past and current urban development processes to predict the environmental consequences of change (Pauleit *et al*., 2005). Nevertheless, it is recognised that the magnitude of change

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is significant and that better data and a better understanding of the causes and effects of land cover change are required (Lambin *et al*., 2001).

Changes in land cover are of particular concern in coastal environments as many are undergoing rapid development due to their attractiveness for residence, leisure, recreation and tourism (Martínez *et al*., 2006, Palmer *et al*., 2010). Larger coastal cities are often associated with ports which attract industry and thus development through the facilitation of the lower of cost sea transportation of goods (Kay & Alder, 2005). Developing countries have experienced high levels of movement of people from the hinterland to coastal cities and settlements (Tibbetts, 2002). It is estimated that, globally, nearly two thirds of the world's population live within 150 km of the coastline. Based on current trends, this may be as high as 75% by 2025 in some regions (Hinrichsen, 1995). Population and development pressure in coastal areas increases impervious surfaces, changes hydrological regimes, disrupts natural habitats, alters aesthetic view-scapes and compromises the sense of place of coastal environments (Crawford, 2007). Developments too close to the high water mark are vulnerable to the natural hazards of erosion, saltwater intrusion, tsunamis and floods (Small & Nicholls, 2003). Examples of this include the devastation wrought by storms such as the cyclone that swept along the coast of Bangladesh in 1997, typhoon "Usagi" in southern Japan, also in 2007, cyclone "Laila" in India in 2010 and, most recently a tsunami in Japan in 2011. In light of this, it is concerning that predictions show that, by 2050, as much as 91% of the world's coastline will be affected by some form of development (Sale *et al*., 2008). People living in the coastal zone will be at the frontline of climate variability and change and will suffer disproportionately from the effects of sea level rise and extreme weather events (WIOMSA, 2011). These growing pressures on the coastal zone highlight the need to change the way we plan and manage coastal development and reinforce the fact that environmental protection and sustainable development are critical for the coastal zone and the ecosystem services that it delivers.

The South African coastline, particularly of KwaZulu-Natal (KZN), is no exception to this trend of rapid development and increasing coastal vulnerability, with the impact of this development becoming increasingly visible along the coast (Preston-Whyte & Oelofse, 2007). This development is driven by improved linkages to the global economy, an increase in some sectors of society's expendable income, changes in policy on environmental management and developers' quests to extend markets to 'undiscovered destinations' (Preston-Whyte & Oelofse, 2007). Significant changes have taken place over a relatively short time, resulting in the need for a retrospective assessment of these changes to better inform management in the future (Tourism KwaZulu-Natal, 2005).

In the case of KZN, coastal development has gone through a number of phases, with development 'booms' being evident for different sections of coast at different times. This paper firstly assesses the current distribution of coastal land cover types in KZN, as this provides insight into the overall state of coastal land cover, land use and development. Secondly, the paper evaluates changes in coastal land cover and resultant land use and development for two sections of coast where historic data are available. This provides a basis for insight into the patterns and rates of change that have taken place along the KZN coast over time.

MATERIALS and METHODS

Study areas

TThis study focuses on the current state of land cover and coastal development along two sections of coast in detail and the changes in land cover that have occurred in these areas over seven decades.

The KZN Province is located on the eastern coast of South Africa and has a coastline of some 580 km (Figure 1). This Province accounts for 21.3% of the country's total population and has an average population density of 104 people per km^2

(Statistics South Africa, 2010). However, the KZN coastal areas are more densely populated, with coastal municipalities having a combined population density of 322 people per km^2, in contrast to inland municipalities which have a population density of only 64 people per km^2 (DEAT, 1999; Statistics South Africa, 2001).

The KZN coast can be divided into five "functional" geographic areas as proposed by the Coastal Policy Green Paper (1998) and the White Paper for Sustainable Coastal Development in South Africa (DEAT, 1999). These areas are, from north to south: Maputaland, Zululand, the Dolphin Coast (together making up the North Coast) and Durban and the Hibiscus Coast (making up the South Coast). These divisions were based on administrative boundaries, biophysical characteristics and major biophysical features, socio-economic profiles and perceived regional identity (Figure 1). Subsequently, municipal boundaries were amended which show little correlation to the original divisions (Figure 1). Nevertheless, there remains a strong biogeographic association with the North and South Coasts, although the former can be further divided into an upper and lower section (Figure 1). The three sections of coast are also of similar geographic extent, allowing for relative comparisons to be made.

Two areas were selected and assessed in detail to interrogate coastal land cover and evaluate potential changes into the future, in terms of historical land cover and changes in cover over time: the North Coast, extending for 130 km from Ballito to Richards Bay, and the South Coast extending for 124 km from just south of Umkomaas to the Mtamvuna Estuary and the border of the Eastern Cape Province (Figure 1).

Historically, large sections of KZN and its coastal zone were part of the fragmented and former homeland area of KwaZulu. Homelands were established under Apartheid legislation and planning. Apartheid, meaning separateness, refers to the policy of separating people based on race. It dictated where people lived, went to school and worked (Clark & Worger, 2011). Prior to the formal establishment of these homelands in 1948, land was largely divided into 'white' areas and 'native' lands through the Land Act of 1913 (Christopher, 2001), and approximately 3.5 million people were resettled between mid-1950 and mid-1980 in terms of this policy (Clark & Worger, 2011). The KwaZulu homeland was created for the resettlement of Zulu people from designated 'white' areas. Homeland territory was governed according to communal tenure, which combined individual and collective property rights. Land held in communal tenure was generally owned by the state or held in trust for specific tribal communities and therefore could not be sold; some not even today (Lahiff, 2003).

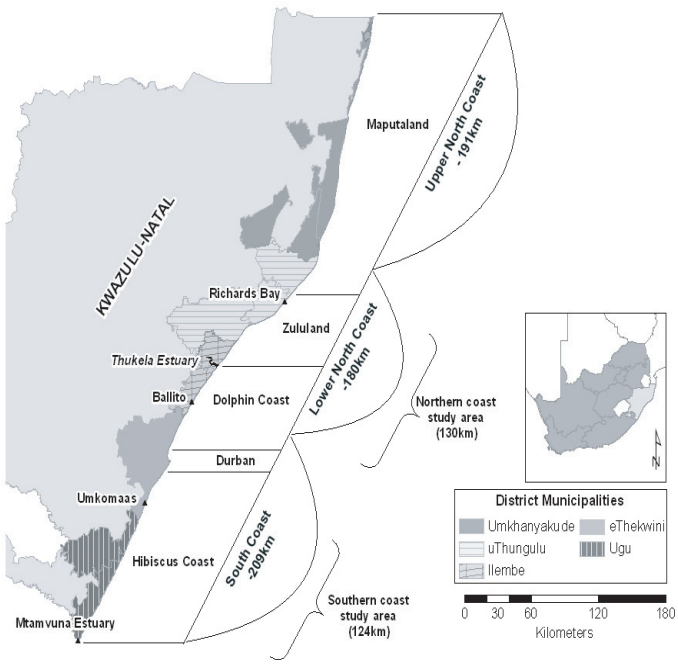

Figure 1. Functional divisions and case study areas on the KZN coast.

For the purpose of this study, the inland boundary of the coastal zone has been defined in terms of the South African Integrated Coastal Management (ICM) Act (Act No. 24 of 2008). In terms of the Act, the coastal zone incorporates five specially designated coastal areas, namely coastal public property, the coastal protection zone, coastal access land, special protected areas and coastal waters. Of these, the coastal protection zone in areas zoned as agriculture or undetermined is defined as the most landward boundary, approximately 1 km inland from the high water mark. This reference line was used as the inland boundary of the coastal zone in this study.

Land cover

Land cover data were captured for the entire KZN coastal zone from composite colour, orthorectified aerial photographs taken in 2008; these were accepted to reflect the current state of coastal land use and development. The historic data were captured from early monochromatic aerial photographs, which were geo-referenced to the 2008 orthorectified photographs. Geo-referencing is the process whereby images are located spatially by 'referencing' images to data of a known coordinate system. Land cover for all three data sets was captured in ArcGIS 9.3 by means of heads-up digitizing. The local area projection of Universal Transverse Mercator (Zone 36) was used. The selection of the study areas and time intervals for the historic assessment were largely based on earlier aerial photographs. As the two study areas were covered for similar period and time intervals, the three time epochs selected for use were 1937, 1973-76 and 2008, which results in 30 and 40 year time-frames, respectively.

Land cover classification for this assessment was based on the South African National Land Cover Project (Fairbanks *et al*., 2000) and Thompson's (1996) land cover classification schemes. Land cover was classified into 29 land cover classes, broadly grouped into four categories: natural land, agriculture and mining land, disturbed land and developed land. *Natural* land cover refers to areas which are considered to be in a natural or near natural state, unaffected by human intervention, including water bodies and significant geomorphic features (dune systems and the littoral zone). *Agriculture and mining* refers to erstwhile natural land that has been converted for commercial and subsistence agriculture, primarily sugarcane farming and forestry plantations, and mining activities. *Disturbed* land is that which has been altered, cleared, disturbed or subsequently left fallow as a result of human activity. *Developed* land refers to man-made structures such as roads, residential houses, factories, parks, and golf courses.

Changes in land cover were identified by means of post-classification change detection; where two (or more) independently classified land covers were compared by means of direct comparison of data (Thompson *et al*., 2001; Ahlqvist, 2008). The advantage of this method is that it is based on informed interpretation and not on numerically-based image analysis (Ahlqvist, 2008) and hence eliminates limitations that may be associated with the 'normalisation' of multi-date imagery. However, when using this method, the accuracy of the outcome is highly dependent on the accuracy of the input data and erroneously captured data will result in false areas of change (Thompson *et al*., 2001).

Inter-class conversions, from one primary land cover category to another, and intra-class transformations within one land cover category, can be observed when assessing land cover change (Thompson *et al*., 2001). This study focused on identifying inter-class conversions that represented major changes from one primary classification to another, such as *natural* to *developed*. The use of Geographic Information System (GIS) software to capture land cover at different time intervals allowed for a spatial and temporal assessment of these inter-class conversions (Palmer *et al*., 2010).

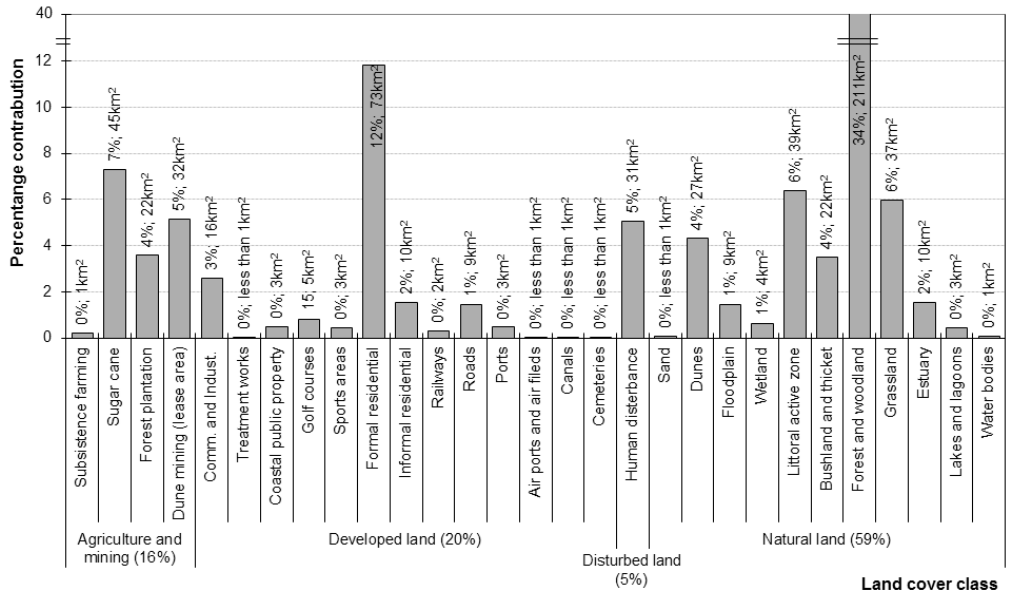

Figure 2. Present land cover in the KZN coastal zone.

RESULTS

Assessment of land cover change

Assessment of current land cover revealed that, at present, approximately 20% of the 1 km wide strip of the KZN coastal zone is classified as *developed*, while a further 16% has been altered for *agriculture and mining* and 5% is *disturbed* as a result of clearing or erosion (Figure 2). Hence, 41% of the KZN coastal zone has been transformed as a result of human activity, while 59% of the KZN coast is considered to be in a *natural* state (Figure 2). Figure 2 also shows a detailed breakdown of land cover for the KZN coast. It reveals that the dominant land cover class is indigenous forest and woodland, accounting for 38% of total land cover, followed by formal residential areas, which account for 12% of land cover for the coastal zone.

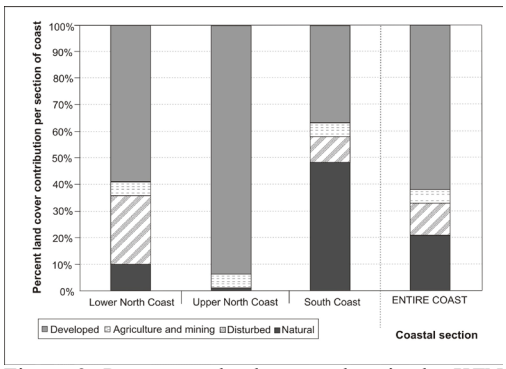

Figure 3. Percentage land cover class in the KZN coastal municipalities.

Significantly, land cover classes are not evenly distributed, in that the *developed* areas of the KZN coast primarily occur on the South Coast (Figure 3, Figure 1), with 48% of this section of coast being *developed*, while *natural* areas occur primarily along both sections of the North Coast, covering 59% and 84% of the upper and lower sections respectively (Figure 3). A significant portion of the north coast (30%) falls within the iSimangaliso Wetland Park, which is a formally protected World Heritage Site and which is predominantly (28% of the 30%) in a *natural* state.

Land cover distribution has changed over time, as reflected in an analysis of the two study areas and depicted in Figure 4. Clearly, there has been an increase in *developed* areas in both the north and south, with a concomitant decrease in *natural* land cover in both areas. *Developed* areas along the South Coast contributed 6% to

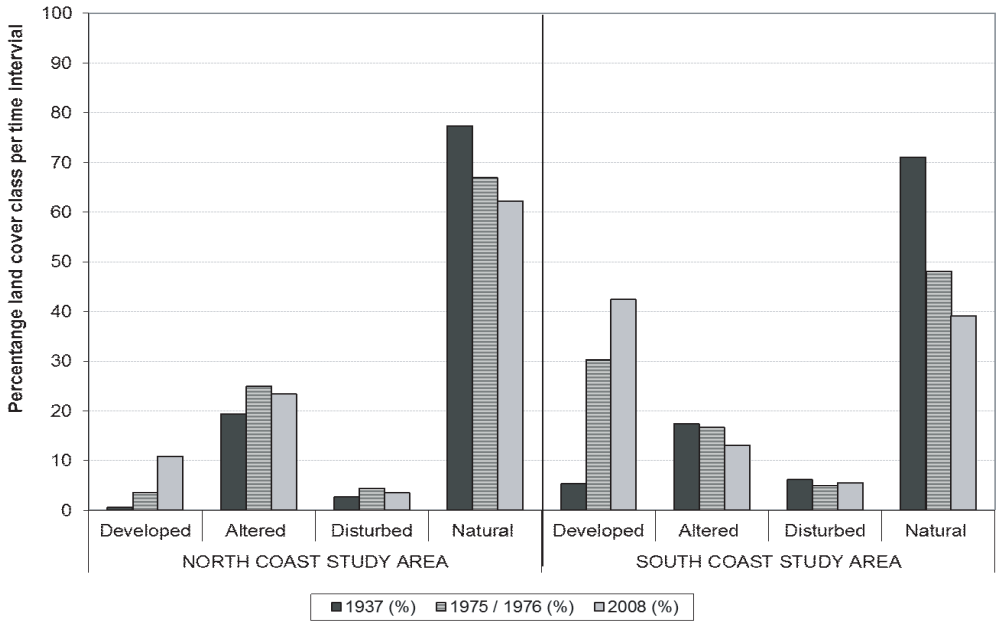

Figure 4. Percentage land cover type along the KZN North and South Coasts.

total land cover in 1937, which increased to 30% in 1973-76 and reached 42% in 2008. This is a five-fold increase in development between 1937 and 1973-76, with a further 12% increase between 1976 and 2008. While "built up" areas contributed less than 1% to land cover along the North Coast in 1937, it increased to 4% in 1973-76. By 2008 *developed* land had increased by a further 7% to contribute 11% to the total land cover in that study area (Figure 4).

Figure 5 shows the extent of this development, as of 2008, in both study areas. From this it is evident that the South Coast portrays extensive ribbon-type development in comparison to the pockets of development along the North Coast. However, there is some concern that the North Coast is starting to mirror that of the South Coast as pressure for developable coastal land increases.

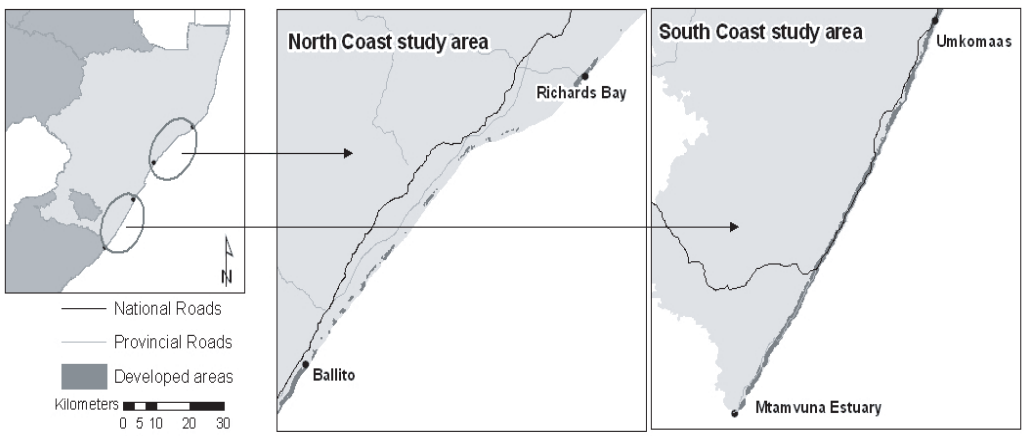

Figure 5. Extent of development and access via major road networks along the KZN North and South Coasts.

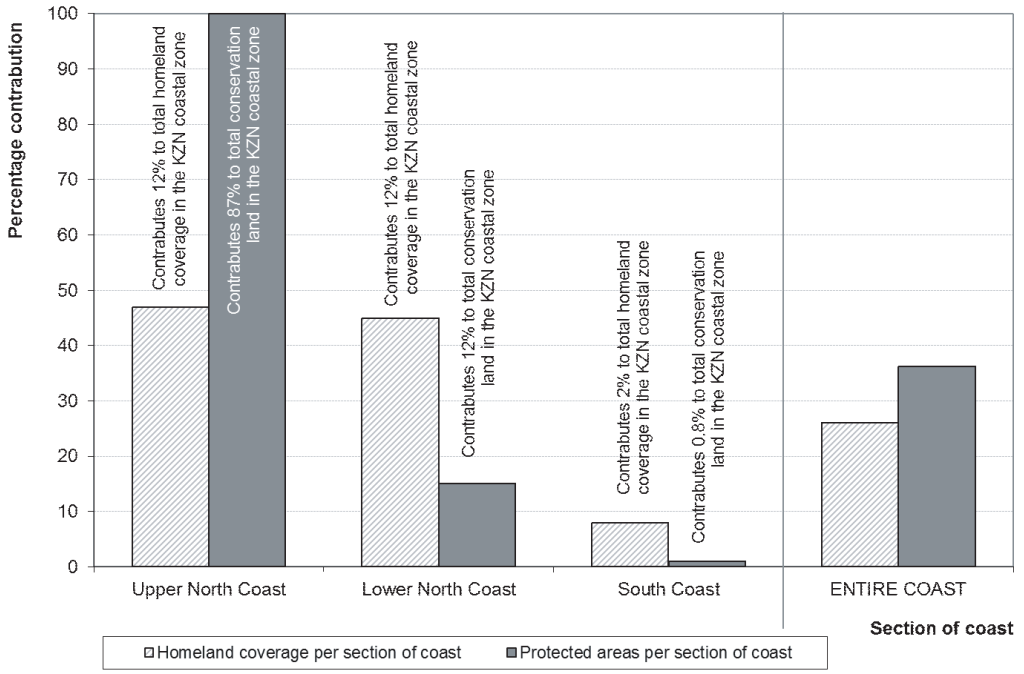

Figure 6. Percentage area of past homelands and conservation areas on the KZN coast.

Several government management policies that have influenced the distribution of land cover types in the past need to be documented. Besides normal coastal development pressures associated with industry, ports, tourism, resources etc., there have also been additional factors such as proclaimed conservation areas and the Apartheid-era homelands. Homelands were zones subjected to severe development dictates, ranging from institutionalised under-development to government-driven industrial zones. Although these homelands were found in all parts of South Africa, many were located in the coastal zone of KZN, accounting for about 26% of the entire 1 km wide coastal strip; 24% being found on the North Coast (Figure 6). The upper and lower North Coast comprised 45% and 47% former homeland areas respectively, contrasting to the South Coast of which only 8% was declared homeland (Figure 6). In addition, conservation areas assumed greater prominence over time; in KZN 36% of the coastal zone has been set aside for this purpose, predominantly in the iSimangaliso Wetland Park, which accounts for 87% of protected coastal land in KZN. In both the homeland and conservation areas, prevailing management regimes generally limited changes in land use; subsequently, such land cannot normally be sold to other parties.

Drivers of spatial development

This study shows that the KZN coast has seen considerable development and transformation, with 36% of the entire coast being permanently transformed as a result of development, agriculture and mining activities, while a further 5% is in poor condition due to poor management (Figure 2). Of the transformed land, 12% has been formally developed for residential and holiday accommodation (Figure 2). There is evidence that development pressure is increasing in the coastal zone of KZN, with applications for the development of board walks, beach promenades, single dwellings and estates more than doubling between 2010 and 2011. However, this phenomenal increase in applications may be a response to a ‘slump’

in development in 2009 and 2010, possibly related to the global economic recession when development applications almost halved from the 2008 application rate Department of Agriculture, Environmental Affairs and Rural Development, unpub. data).

Historic development trends in South Africa have, as a whole, been unusual, primarily affecting the economic hub the inland areas as a result of the discovery of gold and diamonds and the development of associated services and financial industries on the Witwatersrand. This meant that large swathes of the South African coast have remained underdeveloped to this day. In the past few decades, however, there has been a noticeable shift to the coast, partly created through industrial port facilities such as Richards Bay and Saldanha Bay (Glavovic, 2000). Notwithstanding the slow pace of coastal development in South Africa, some regions have experienced unusually intense development. The KZN South Coast was one such area, which developed primarily as a middle-class, urban and mostly white tourist destination. This coast's relative proximity to the Witwatersrand and ease of access through existing road infrastructure (Figure 5 shows the current coastal access), its safe swimming beaches, year-round warm climate and largely non-homeland status led to a development boom (Preston-Whyte & Oelofse, 2007). The South Coast also offered existing infrastructure and services through historical developments such as the Port and town of Port Shepstone, the railway line and the town of Margate in the late 1800s and early 1900s. This increase in development is evident in Figure 4, where the South Coast study areas developed coverage increased five-fold between 1937 and 1973-76, to contribute 30% to total land cover in this area. While this development 'boom' led to the establishment of the coastal towns of Scottburgh, Uvongo, Southbroom and Hibberdene, it also resulted in poorly managed ribbon development along this coast (Figure 5; Preston-Whyte & Oelofse, 2007).

Notwithstanding the high rate of development along the South Coast, there initially was very little evidence of development along the North Coast, contributing only 4% to total land cover by 1973-76. In part, this can be attributed to the fact that much of the north coast (21%) was homeland area, compared to only 7% on the South Coast. Lack of development along the North Coast is also in part due to the inaccessibility of these sections of coast. Even today, development is strongly associated with areas that have existing road infrastructure (Figure 5).

Shortly after World War Two (WW-II), agriculture in South Africa expanded (Biggs & Scholes, 2002), including along the KZN coastal strip, mostly in the form of sugar cane and timber farming. This is evident in the 1937 historical data, where 19% of the North Coast and 17% of the South Coast was occupied by agriculture and mining land (Figure 4). However, there was a progressive decrease in altered land cover between 1937 and 1973-76, which resulted from sugarcane areas being converted into developed land in order to meet tourist accommodation needs (Biggs & Scholes, 2002).

Since the 1970s, diversified development along the coast has intensified (Glavovic, 2000). This has been driven largely by service industries, tourism, resort development and activities related to import/export from ports (DEAT, 2006). Evidence of this can be seen along both the southern and northern coasts of KZN. Along the North Coast, development increased to 11% between 1973-76 and 2008, increasing from its original level in the 1930s by 95% (Figure 4). This increase was partly attributable to the construction of Richards Bay harbour in 1970s, with its associated industries such as a coal terminal, paper mill, fertilizer plant and aluminium smelter – all thought to be important to the development of KZN and South Africa (Glavovic, 2000). These developments were considered to be 'coast dependant' due to the need for the proximity of and access to the port. In addition, coastal areas north of eThekwini have gained attention from high-end tourism resort developers who offer "a secure lifestyle, breathless views, eco-friendliness and access to pristine coastlines" (Preston-Whyte & Oelofse, 2007).

Plate 1: Damage to the coast under marginally high seas (Umdloti Beach - June 2011). (Source: Oceanographic Research Institute, Durban)

Plate 2: Damage to buildings as a result of the 2007 extreme weather event (Ballito, KZN North Coast – March 2007). (Source: Simon Bundy)

A key consideration for future development is that structures built close to the high water mark are becoming increasingly vulnerable to the effects of coastal erosion, storms and extreme weather events. In KZN, there is evidence of damage both as a result of winter swells (Plate 1) and from extreme weather, which are becoming more frequent. An example of this was the March 2007 storm event, when millions of Rand in damage occurred to infrastructure and buildings (Plate 2, Smith *et al*., 2007). Development should be set back from the high water mark to ensure the natural functioning of the coast and to prevent damage to infrastructure and properties.

DISCUSSION

The need for development is patently clear, especially that which creates livelihoods in an environmentally sustainable way. Defining appropriate targets for and threshold levels of development may not be easy, but clearly the ecosystem services that have attracted development to the coast in the first place should not be compromised.

Based on the results, 59% of the KZN coast has not yet been developed or altered (Figure 2), of which a significant proportion (30%) falls within the protected iSimangaliso wetland park. The remainder of the coast's undeveloped *natural* land falls predominantly along the North Coast (Figure 5) where development pressure is on the increase. This is driven by improved access in road infrastructure and the new King Shaka Airport. Planned developments in mining and large-scale tourism destinations are likely to cover a significant proportion of coastal land in the near future, leaving a disconcertingly small section of *natural* land. This will present a challenge in terms of the need for wise management of land in the coastal zone, which must be considered in the assessment of proposed developments and future activities. The conservation of the coastal zone will be imperative to ensure its natural functioning and continued delivery of goods and services.

Some respite is at hand, as new mechanisms have been put in place through the Integrated Coastal Management Act (ICM Act No. 24 of 2008) that allow for the enforcement of better coastal management in South Africa. This incorporates the provision of coastal set-back lines, which ensure that future developments are *set back* a reasonable distance from the coastline in order to protect the natural functioning of the coast. This, in conjunction with other spatial planning guidelines and legislation, allows

for the management of future development in a manner which will ensure maximum benefits from the remaining non-developed areas and associated ecosystem services. This will include a strong drive towards a more equitable distribution of natural areas, in recognition of the ecological difference between the southern and northern regions of KZN. Further development should be appropriately linked to the coastal environment. For example, heavy industries, airports and football stadiums are not necessarily dependent on or appropriately located at the coast. Any additional development should, as far as possible, be contained within existing urban nodes to prevent further ribbon development along the coast (Palmer *et al*., 2010). The North Coast, having a low level of development (Figure 4), still provides the opportunity to avoid the poor land use patterns evident along the South Coast. Effective implementation of the legislation will ensure that future development will be contained within existing development nodes or in areas of low environmental sensitivity, and that sensitive coastal areas are protected and their ecological functioning maintained.

Management of expanding urban areas along the coast will be one of the most difficult tasks. The value of coastal land for residential and tourist developments results in the conversion of agriculture and other low intensity land uses to urbanization (Kay & Alder, 2005), as urban areas offer the potential for increased income through the expansion of the rates base. This often leads to urban ribbon-type development and the joining of cities hundreds kilometers apart into 'mega cities' as has happened to San Paulo and Rio de Janeiro (Kay & Alder, 2005). However, authorities should bear in mind that development in the coastal zone, particularly too close to the high water mark, brings with it its own host of problems as has occurred in Bangladesh, Japan and India.

Assessment of the current state of coastal land cover in KZN has revealed that 36% is permanently transformed as a result of human activities, which has rendered the coast vulnerable to the effects of coastal erosion, storms and extreme weather events, as is evident in Plates 1 and 2. Furthermore, this paper shows that the KZN coast has undergone intense but unequal development pressure over the past 70 years. There is every reason to believe that the demand for further development will continue, especially in the remaining *natural* or non-developed areas on the North Coast.

The coastal zone is a finite resource and should be managed as such, hence the development and promulgation of the ICM Act. The effective implementation of this Act will be key in ensuring long-term sustainability in the coastal zone in South Africa. The KZN province still has the opportunity to manage future development in its coastal zone in accordance with this legislation by ensuring that they are undertaken in an environmentally sound manner and do not impede on or disrupt the natural functioning of the coastal environment. If this is not achieved, the ecological functioning of this system will be affected, making it more susceptible to degradation, coastal erosion and extreme weather events (Palmer *et al*., 2010). This, in turn, will reduce its ability to sustain coastal livelihoods and support recreation and tourism activities, the very reason why these areas have been and are being developed in the first place.

The Apartheid-era constraints on the development of homeland infrastructure were notoriously retrogressive and socially flawed. Nevertheless, one way of reversing this negative perspective will be to ensure that the homeland regions are wisely developed with an appropriate balance between *natural* and *developed* areas in future. There is still an opportunity to undertake an inventory of ecosystem services along the KZN coast to inform future policy regarding targets and thresholds for the location and scale of different land-use types in the Province's valuable but vulnerable coastal zone.

CONCLUSION

This analysis has shown that development along the KZN coast has occurred over a relatively short period, with development being largely concentrated along the southern section of the coast due to its greater accessibility to the hinterland. The northern section of the coast, now more accessible, is experiencing increasing pressure for development.

While development in coastal areas is inevitable and can be good for the economy and well-being of coastal communities, it has to be effectively regulated and managed. It is essential that natural coastal functioning be maintained, not only to ensure that ecosystem goods and services are delivered but also to prevent damage to coastal developments as a result of coastal storms and extreme weather events.

Future research should consider coastal development and land use change post-enactment of the ICM Act and the effectiveness of management interventions.

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