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Coastal access situational analysis for KwaZulu-Natal: 2006.

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Description:	The aim of this project was to collect and provide information related to access to the seashore along the KwaZulu-Natal coast. Public access to the shoreline has been and always will be of great social and economic importance to people across the globe. Access to the shoreline of South Africa is a fundamental element of the Integrated Coastal Management Bill (2006) and will be the responsibility of local municipalities. There are 11 coastal local municipalities falling within 5 coastal district municipalities. These five coastal district municipalities are the areas of focus in this study. Access routes were digitised from orthorectified aerial photographs taken in 2006 of the entire KwaZulu-Natal coastline using ArcInfo at a map scale of 1:1000. These routes were classified, databased and analysed for trends in their characteristics along the coastline. This data report highlights the preliminary descriptive results for the five coastal district municipalities highlighting the differences in coastal access characteristics between these municipalities. It also provides recommendations for further analyses.
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Coastal access situational analysis for KwaZulu-Natal: 2006

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INTRODUCTION

Public access to the coastline of KwaZulu-Natal (KZN), South Africa is of great economic and social importance. KZN's coastal local municipalities occupy approximately 15% of the province's total physical area (km^2) and the population numbers in this area amount to nearly 50% of KZN's total population (Statistics South Africa 2001). As such, this implies an enormous need for providing responsible and equitable public access to coastal public property.

Coastal public property is of great cultural, historical and spiritual significance in KZN. Access to this area allows for recreation, leisure, education, scientific opportunities and overall improvement of both mental and physical well-being (Evett 2005). From an economic perspective public access is critical in supporting the tourism sector which is one of South Africa's fastest growing economic sectors. In 2005, approximately 1.6 million foreign and 11.6 million domestic tourist trips were made to KZN with the average amount spent per trip being R5 220.00 and R583.00, respectively, making the total market value approximately R8.3 and R6.28 billion, respectively (The Southern Africa Tourism Services Association 2006). The top three activities undertaken by domestic visitors in KZN in 2003 were going to Nature reserves (25%), watching live sports (28%) and going to the beach (71%) (KwaZulu-Natal Tourism Authority 2004). The respective top three activities for foreign tourists were beaches (73%), the nightlife (83%) and shopping (90%) (The Southern Africa Tourism Services Association 2006). Therefore both domestically and internationally the KwaZulu-Natal coastal zone is of great socio-economic importance.

Historically, public access to the shoreline took the form of street ends, boat ramps, parks, and public piers. In addition to these waterfronts, view corridors and designated rights-of-way have been developed in an attempt to increase public access to the much desired shoreline. However, industrial, commercial and residential development along the coastal zone have limited, and at times eliminated, public access to this area and as such placed restrictions on public usage of its numerous resources.

Providing public access to coastal public property in South Africa is a fundamental element of the national Integrated Coastal Management Bill (2006) and the responsibility of local municipalities (Department of Environmental Affairs and Tourism 2006). It is their responsibility to clearly sign post entry points, control the usage of and activities on this land, protect and enforce the rights of the public, where possible provide facilities that encourage access e.g. parking areas, toilet areas, boardwalks etc., ensure infrastructure does not result in adverse environmental impacts and remove any existing areas that do so. In addition, each access area must be described or indicated in municipal management programmes, integrated development plans and/or spatial development programmes and a report must be submitted to the provincial member of the Executive Council (MEC) responsible for the designated provincial lead agency on what measures have been taken to implement these responsibilities.

This study provides information on the status of coastal access areas KZN with the intended application as a management tool for municipalities in the province.

METHODS

1. Study Area

This study was conducted along the coastline of the KwaZulu-Natal (KZN) province in South Africa (Figure 1). This South African province is divided into 11 District Municipalities of which 5, namely UGU, eThekwini, Ilembe, uThungulu and Umkhanyakude are coastal.

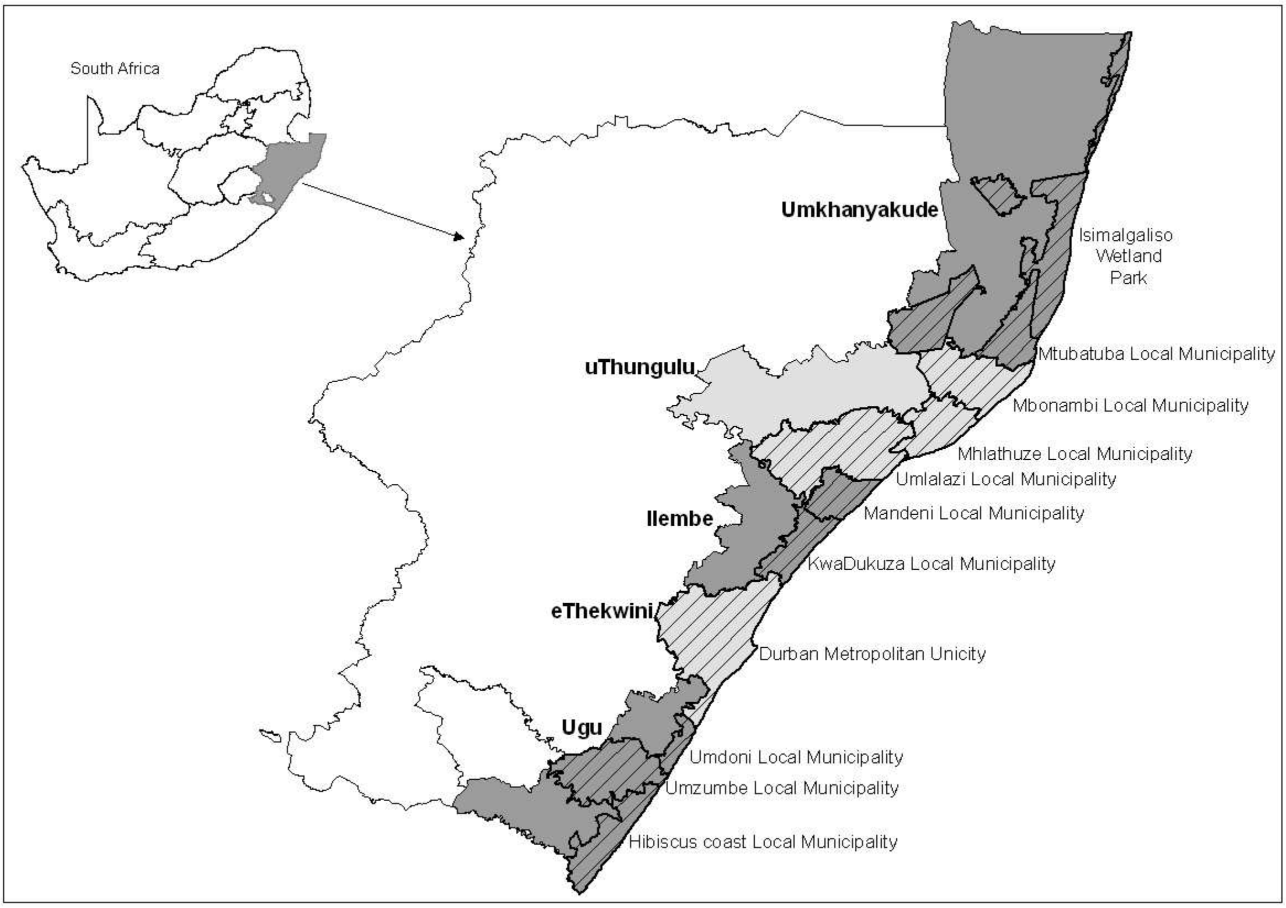

Figure 1. Location of KwaZulu-Natal in South Africa and the boundaries of the five coastal District Municipalities and their coastal Local Municipalities.

a) The Ugu District Municipality has a coastline of approximately 143km long stretching from the Eastern Cape Province in the south to the eThekwini District Municipality in the north. It is divided into 6 Local Municipalities of which 3, Hibiscus-Coast, Umzumbe and Umdoni, are coastal (Figure 1). The beaches along this stretch of the coast are predominantly coarse and sandy separated by estuaries and rocky headlands (Coastal Management Policy Programme 1998). The Ugu coastline is also the second most popular tourism destination in KZN (Our beaches (n.d.)) with multiple uses and demands on its natural coastal resources.

b) The eThekwini District Municipality is the metropolitan municipality with one of the most significant seaports in the world namely, the Port of Durban, and is the main economic driver in KZN (KwaZulu-Natal Top Business Portfolio 2005). With a coastline of approximately 93km from Scottburgh in the south to the Tongaat River in the north it has the smallest coastal stretch in the province. Its beaches are backed by low dunes and are predominantly long, course, and sandy. The coastal areas are in high demand for a wide variety of recreational uses.

c) The Ilembe District Municipality's coastline extends from the Tongaat River in the south for 86km to the southern boundary of the Umlalazi Nature Reserve in the north. It is consists of 4 Local Municipalities of which two are coastal (Figure 1) and is situated between the KZN harbors, namely Durban and Richards Bay. Its beaches are course, sandy and enclosed by rocky outcrops (Coastal Management Policy Programme 1998) which are popular fishing areas. In addition, the coastal area north of the Tugela River consists of the only major prograding dune system along the coastline of KZN which extends to the Mlalazi River (Flemming & Hay 1988).

d) The uThungulu District Municipality coastline falls in the flat coastal region known as the Natal Coastal Belt and extends for approximately 98km from Gingindlovu in the south to just north of Cape St. Lucia in the north. It has 6 Local Municipalities of which Umlalazi, uMhlathuze and Mbonambi are coastal (Figure 1). Its beaches are long sandy beaches backed by broad coastal plains and high forested dunes (Coastal Management Policy Programme 1998). The largest deepwater port in Africa is situated along this coastline, namely Richards Bay which is has double the capacity of the Port of Durban (KwaZulu-Natal Top Business Portfolio 2005).

e) The Umkhanyakude District Municipality has the longest stretch of coastline along KZN extending 178km from just north of Cape St. Lucia to the international border between Mozambique and South Africa. It has 5 Local Municipalities of which Matubatuba and the Isimangaliso Wetland Park are coastal (Figure 1). The coastline has wide sandy beaches, forested dunes and interconnected freshwater and estuarine lake systems (Coastal Management Policy Programme 1998). The majority of Umkhanyakude's coastline falls within the Isimangaliso Wetland Park within which Marine Protected Areas have been proclaimed for most coastal areas and zoned for different levels of human use. Eco-tourism and fishing are important activities along this culturally and environmentally important coastline.

2. Definitions:

A. Coastal access land is land (strips of land) adjacent to coastal public property specifically designated for the use of the public to gain access to that coastal public property (Department of Environmental Affairs and Tourism 2006, pg 28).

B. Coastal access point is the end node or point of a coastal access route limited to the vegetation line.

C. A coastal access route is course of travel leading to coastal public property.

D. Coastal public property consists of coastal waters, land submerged by coastal waters, seashore, any admiralty reserve and any state owned land declared to be coastal public property in terms of section 8 of the ICM (2006) (Department of Environmental Affairs and Tourism 2006, pg 22-23).

E. The coastal zone is "...the area comprising: coastal public property, the coastal buffer zone, coastal protected areas, and includes any aspect of the environment on, in and above them;" in the Integrated Coastal Management Bill (Department of Environmental Affairs and Tourism 2006 pg13).

F. The seashore is all land and water between the low-water mark and the high-water mark including coastal cliffs from the base to the crest of the cliff according to the Sea-Shore Act 1935 (Department of Environmental Affairs and Tourism 2006, pg 19).

3. Methodology:

Coastal access routes were identified and digitised, from digital orthorectified aerial photographs of the entire KwaZulu-Natal (KZN) coastline taken in 2006, using ArcInfo Geographic Information System at a map scale of 1:1000. Individual access routes were consistently digitised from inland towards the seashore and snapped at the nodes where routes diverged and/or converged. Access entry and exit points were derived from these routes as F and Tnodes, respectively.

These routes were then assigned descriptive attributes, e.g. Unique ID, simple cluster number and complex cluster number. Where a simple cluster: always starts at a primary route entry point and ends at the seashore and may be one in which a primary access route diverges/splits into further routes leading to the seashore (Figure 2a) or one in which more than one primary access route converges to share a common route to the seashore (Figure 2b). A complex cluster is one in which simple clusters are interconnected.

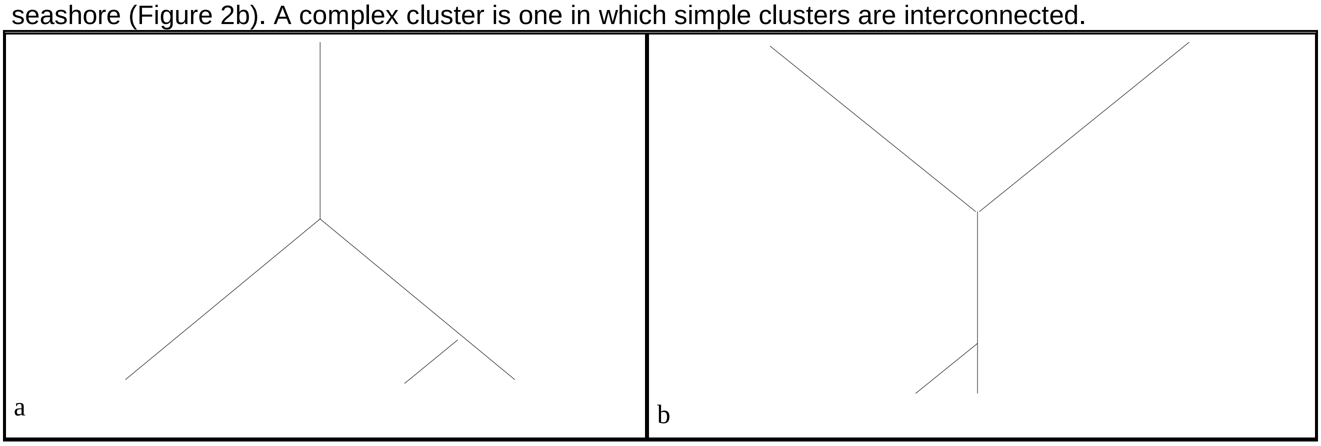

Figure 2. A diagrammatic representation of a simple complex as a result of a) primary route divergence and b) primary route convergence.

In addition, all access routes were classified/categorised by surface type and hierarchy. Surface type had two categories namely, hard and soft. Hard surfaces were artificial surfaces such as concrete, paving and wood. Soft surfaces were grass and sand. The hierarchical categories were as follows:

1. A **primary** access route is one that begins at a feature and is the dominant route leading to coastal public property. Primary access routes may
    a. Diverge equally into multiple routes maintaining the same route width which remain primary routes.
    b. or
    c. Diverge into multiple narrower routes which as a result become secondary routes.
2. A **secondary** access route is one that is narrower in width than the primary access route at which it begins and
    a. leads to coastal public property.
    b. or
    c. leads to another primary access route.
3. A **tertiary** access route is one that is narrower in width than the secondary access route at which it begins and
    a. leads to coastal public property.
    b. or
    c. leads to another secondary access route.
4. A **quaternary** access route is one that is narrower in width than the tertiary access route at which it begins and
    a. leads to coastal public property.
    b. or
    c. leads to another tertiary access route.
5. A **quinary** access route is one that is narrower in width than the quaternary access route at which it begins and
    a. leads to coastal public property.
    b. or
    c. leads to another quaternary access route.

After each route was described and classified, length and direction were calculated. Length is the total length of the access route, in meters, and direction is the angle of the route from North (0^o), i.e. East is 90^o, South is 180^o, and West is 270^o.

Secondary data namely, entry and exit nodes, cluster areas, cluster centre points and distances between points were derived from this data set. Access routes (polylines) were converted to nodes and the Fnodes of primary routes extracted as entry points and the Tnodes extracted as exit points. The Tnodes were further edited to ensure only Tnode occurring along the vegetation line were included. Distances between both entry and exit points were calculated via conversion of the extracted nodes to a polyline file ordered according to the y-coordinate of each point. Mean distances between entry points and exit points were calculated as the distance of each entry point from the polyline derived from the exit points using the ArcInfo “Near' function.

Cluster areas were determined by extracting all access routes that contained a cluster number and converting them to their vertex points. This resulting point file was converted to a polygon file according to complex number and edited in the attribute table using the field calculator to convex polygons. The centroids of these polygons were derived via conversion from polygon to centre points. The distances between these points were calculated via conversion to a polyline file according to the y-coordinate and the length between each vertex calculated.

4. Database & queries.

Separate geodatabases were created for access routes, nodes and convex polygons. The access route geodatabase contained the individual municipality’s access routes and merged file containing all the KZN access routes. The nodes geodatabase contained entry point, exit point and polyline distances between each of these for each municipality. In addition it contained merged files for all KZN entry points, exit points, polylines between them and the distances between entry and exit points along the entire KZN coastline. The convex polygon geodatabase contained convex polygon files for each municipality, a merged polygon file for the whole KZN coastline and a centroid point file derived from this file. Additionally the polyline file containing the distance between these centroids was included.

These geodatabases were queried for: total number of access routes per municipality, average length of access route per municipality, average direction of access routes per municipality, number of access routes in each hierarchy per municipality, the average length of access routes in each hierarchy per municipality, the average angle of access routes in each hierarchy per municipality, the total number of access routes per hierarchy for the entire KZN coastline, total number of simple clusters, total number of complex clusters, the average distance between clusters in each municipality, total number of entry and exit points per municipality, the average distance between entry points, average distance between exit points, average distance between entry and exit points and the total number of hard, soft and combination access routes per municipality.

RESULTS

Descriptors of coastal access in KwaZulu-Natal (KZN) were derived from queries on the above described geodatabases. Descriptor quantities for a) the entire coastline and b) individual district municipalities (DMs) were determined.

a) Entire coastline

Table 1. Coastal access descriptors for the entire KwaZulu-Natal coastline and their corresponding quantities.

Descriptor	**Quantity**
Total number of access routes	5685
Average length of access routes	61.6m (± 130.6m)
Average direction of access routes	120^o ($\pm 53^o$)
Number of routes per kilometre of coastline	9/km
Total number of Hierarchy 1 access routes	4195
Total number of Hierarchy 2 access routes	1146
Total number of Hierarchy 3 access routes	306
Total number of Hierarchy 4 access routes	33
Total number of Hierarchy 5 access routes	5
Average length of Hierarchy 1 access routes	63.9m (± 132.6m)
Average length of Hierarchy 2 access routes	64.3m (± 140.4m)
Average length of Hierarchy 3 access routes	26.7m (± 40.9m)
Average length of Hierarchy 4 access routes	30.9m (± 31.6m)
Average length of Hierarchy 5 access routes	4.3m (± 0.6m)
Average direction of Hierarchy 1 access routes	118^o ($\pm 47^o$)
Average direction of Hierarchy 2 access routes	123^o ($\pm 65^o$)
Average direction of Hierarchy 3 access routes	124^o ($\pm 63^o$)
Average direction of Hierarchy 4 access routes	123^o ($\pm 66^o$)
Average direction of Hierarchy 5 access routes	157^o ($\pm 67^o$)
Total number of simple clusters	743
Total number of complex clusters	82
Total number of hard surfaced access routes	288
Total number of soft surfaced access routes	5277
Total number of access routes consisting of both hard and soft portions	120
Total number of entry points	3667
Total number of exit points	4323
Average distance between entry points	164.5m (±758m)
Average distance between exit points	135.3m (±664.6m)
Average distance between entry and exit points	59.5m (±103m)
Average simple cluster area	$19568.3m^2$ ($\pm 88841.6\ m^2$)
Average distance between simple clusters	776.7m (±2248.7m)
Average number of access routes in simple complexes	4.3 (± 4.5)
Average number of simple complexes in complex clusters	2.3 (± 2.2)
Average number access routes in complex clusters	12.5 (± 12.6)

b) District municipalities

Spatial differences in coastal access along the KZN coast were determined using the descriptors listed in Table 1 for each district municipality. The following results are displayed from north (left/top) to south (right/bottom).

The number of coastal access routes increased from north to south with the exception of the Uthungulu DM with the average access route length showing the opposite trend, i.e. decreasing from north to south. The range in a) number of access routes was from 236 in Uthungulu to 2368 in the Ugu DM, and b) the average length of access routes was 40-176m (Figure 3). The number of access routes in each DM corresponds to the increase in coastline length from Ilembe southwards and northwards, however there were considerably lower numbers of routes along the Uthungulu and Umkhanyakude coastlines (Figure 4).

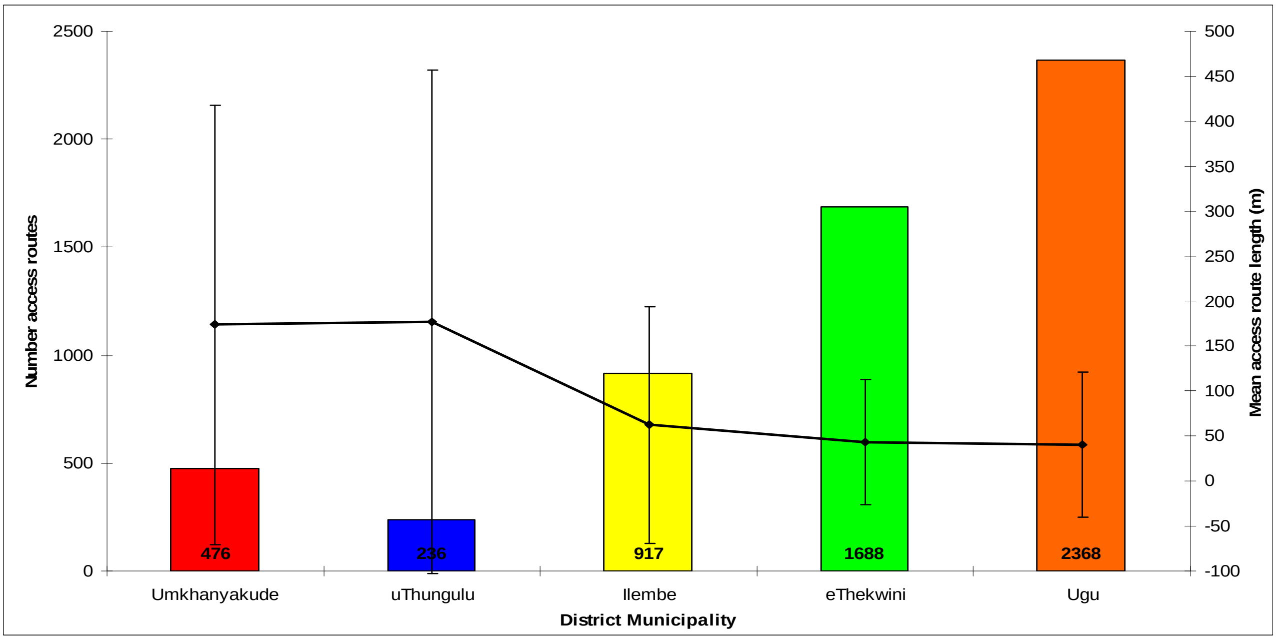

Figure 3. Total number of access routes per KZN district municipality (bars) and their average lengths (m) (line) including their standard deviations indicated by the error bars.

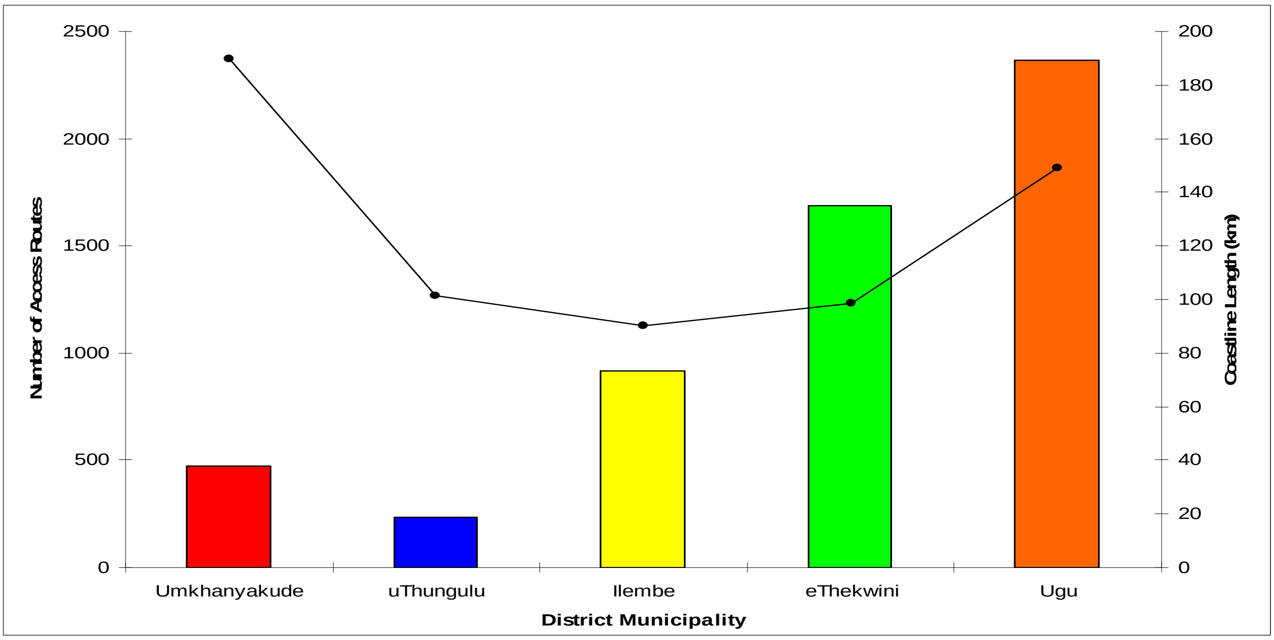

Figure 4. Total number of access routes (bars) and total length of the coastline (line) per district municipality.

The average number of access routes per kilometre (km) of coastline was highest for eThkewini followed by Ugu and lowest for Uthungulu and Umkhanyakude (Figure 5). A general decrease in mean access route length occured from north to south as described above (Figure3 and 5).

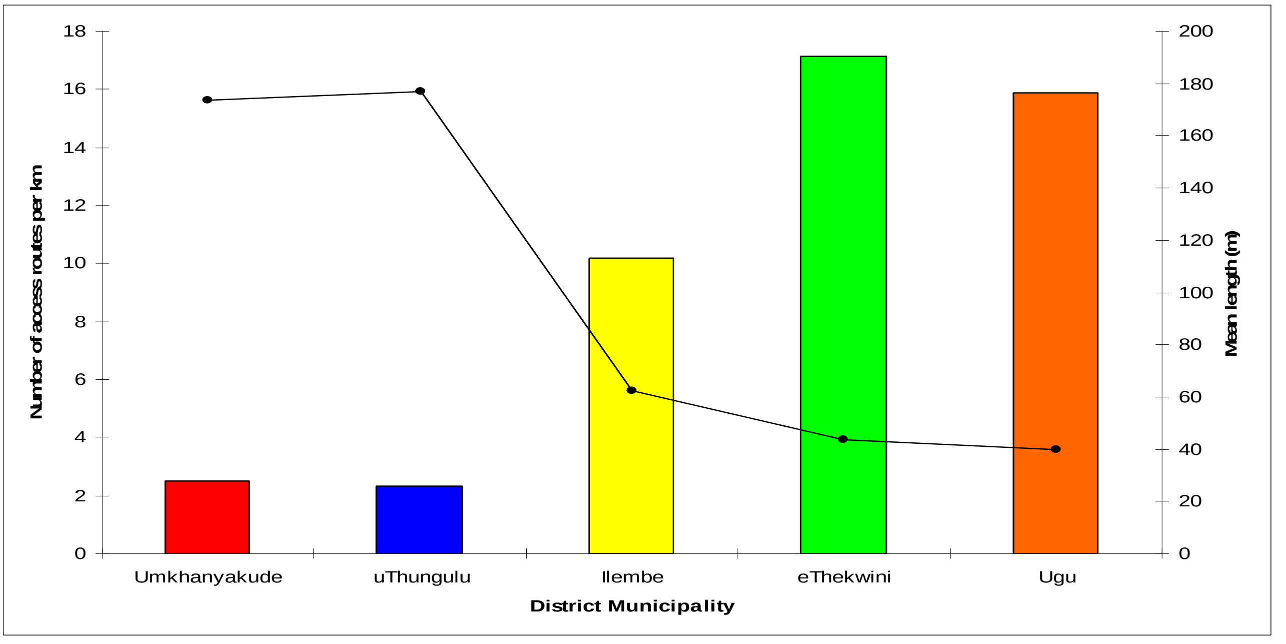

Figure 5. Number of access routes per kilometre (km) of coastline and the mean length (Line) of access routes per district municipality.

The mean direction of access routes in each DM illustrates the differences in the angle of Uthungulu and Umkhanyakude access routes in comparison to the other three DM, where the mean Uthungulu access route direction was a more southerly one and the Umkhanyakude mean direction is a more easterly one (Figure 6).

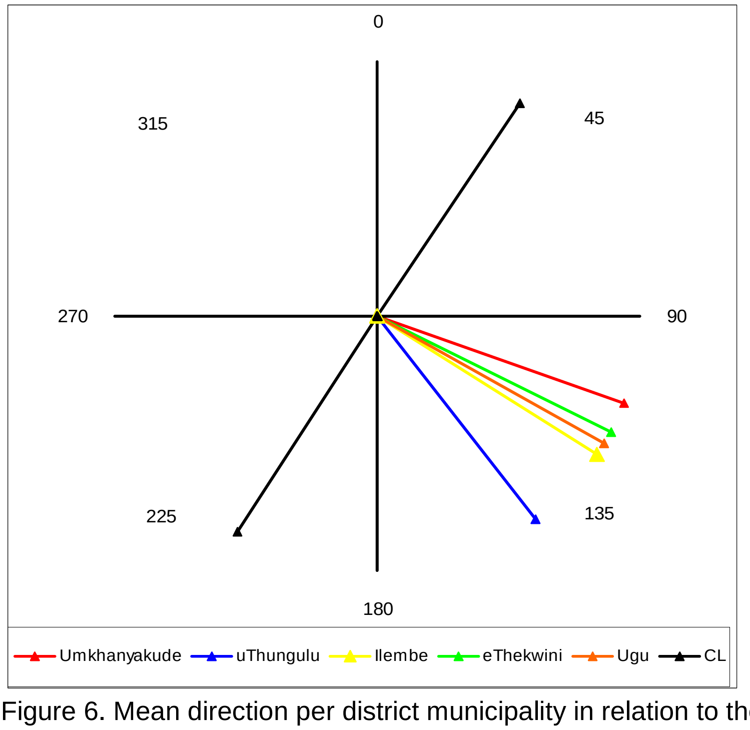

Figure 6. Mean direction per district municipality in relation to the mean direction of the KwaZulu-Natal Coastline (CL)

Frequency distribution plots for both length and direction provide further detail on the access route characteristics (Figure 7 and 8). The length frequency distributions show a decline in presence of longer access routes from north to south with an increase in frequency indicative of the number of access routes per DM. (Figure 7).

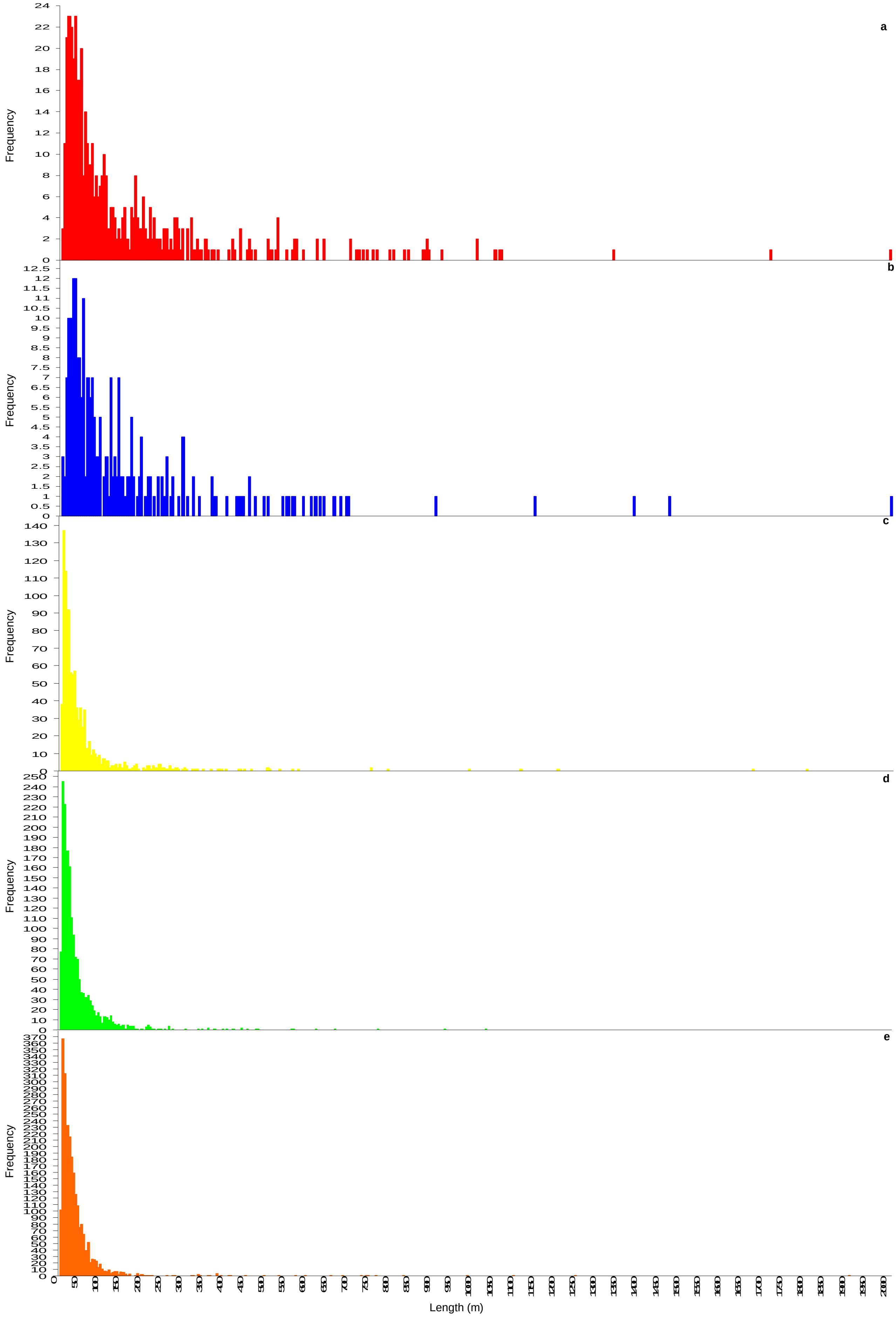

Figure 7. Length (m) frequency distributions by district municipality: a) Umkhanyakude, b) Uthungulu, c) Ilembe, d) eThekwini and e) Ugu.

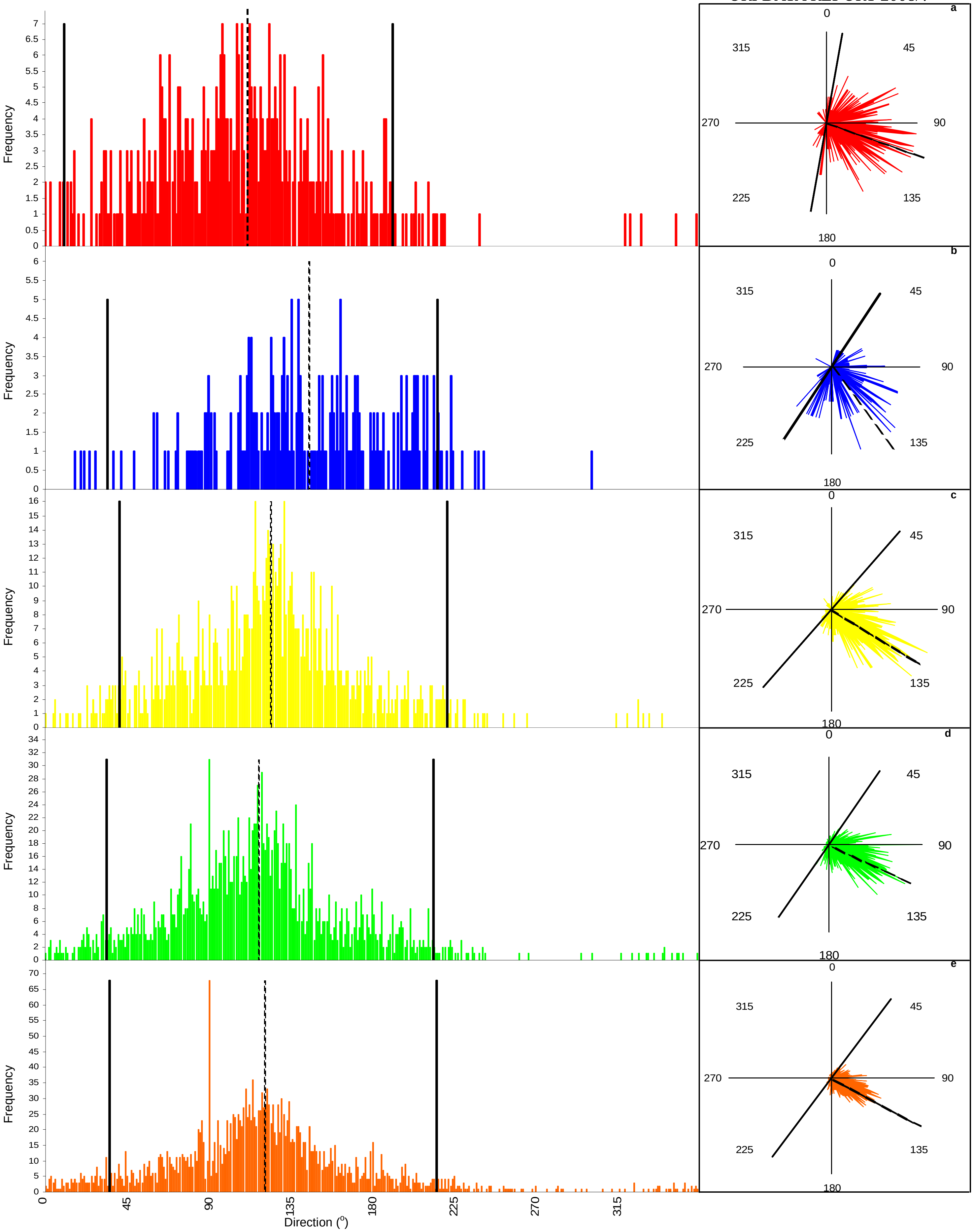

Figure 8. Direction (°) frequency distributions by district municipality (DM): a) Umkhanyakude, b) Uthungulu, c) Ilembe, d) eThekwini and e) Ugu. Indicating the mean direction of the coastline (solid line) and average direction (dashed line) for each DM.

Direction frequency plots illustrate the differences in the average direction of the coastline for each DM and thereby indicating the directional frequency of access routes in relation to this mean (Figure 8). The direction frequency distribution of the Uthungulu DM indicates a lower proportion of the access routes were perpendicular to the coastline i.e. mid direction between the mean coastline direction (Figure 8).

There was a decrease in the number of routes with an increase in hierarchy for all DM's with hierarchy 5 access routes only occurring in the Ugu DM (Figure 9). The mean length of access routes for each hierarchy decreased with a decrease in hierarchy for the Umkhanyakude, Uthungulu and Ilembe DM's (Figure 9). In the eThekwini DM the quaternary access routes were on average longer than tertiary routes which also occurred in the Ugu DM for both quaternary and secondary access routes (Figure 10).

Length frequency distribution plots for each hierarchy provide further detail on the characteristics of the access routes in these categories for each municipality (Figure 11a and b). The frequency of routes longer than 200m was highest in the Umkhanyakude, Uthungulu and Ilembe districts for hierarchy 1 and 2 (Figure 11 a). The access route length (m) at which the length frequency peaks increased from the Umkhanyakude district to the Uthungulu district and decreased southwards for Hierarchy 1 access routes (Figure 11a, a1-e1). The hierarchy 2 length at which the length frequency peaks decreased from the Umkhanyakude DM to the Ilembe DM, increased for eThekwini and decreased again for Ugu (Figure 11a, a2-e2). The Umkhanyakude DM had the highest frequency of routes longer than 200m (Figure 11b). The length at which the length frequency peaked for hierarchy 3 access routes is lowest for the Ilembe DM, followed by eThekwini, Ugu, Umkhanyakude and lastly the Uthungulu DM (Figure 11b, a3-e3). The length frequency distributions for hierarchy 4 access routes followed the same general pattern as the hierarchy 3 routes additionally, both the Ilembe and eThekwini DM only had one quaternary access route increasing southwards to the Ugu DM which had the highest number and the shortest quaternary routes (Figure 11b, a4-e4).

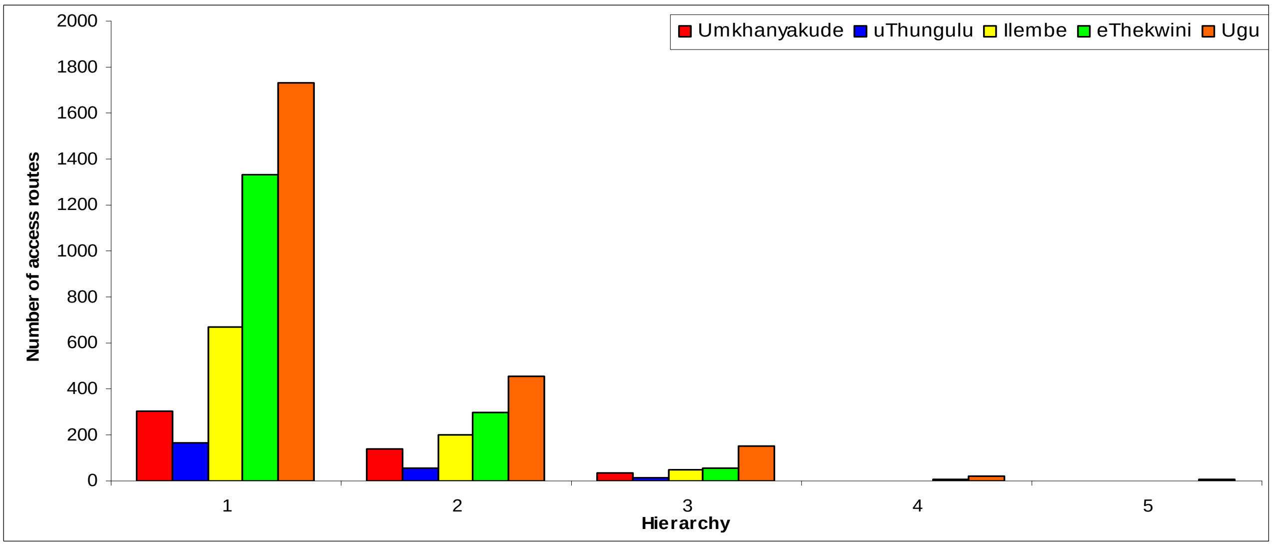

Figure 9. Total number of access routes per municipality per hierarchy.

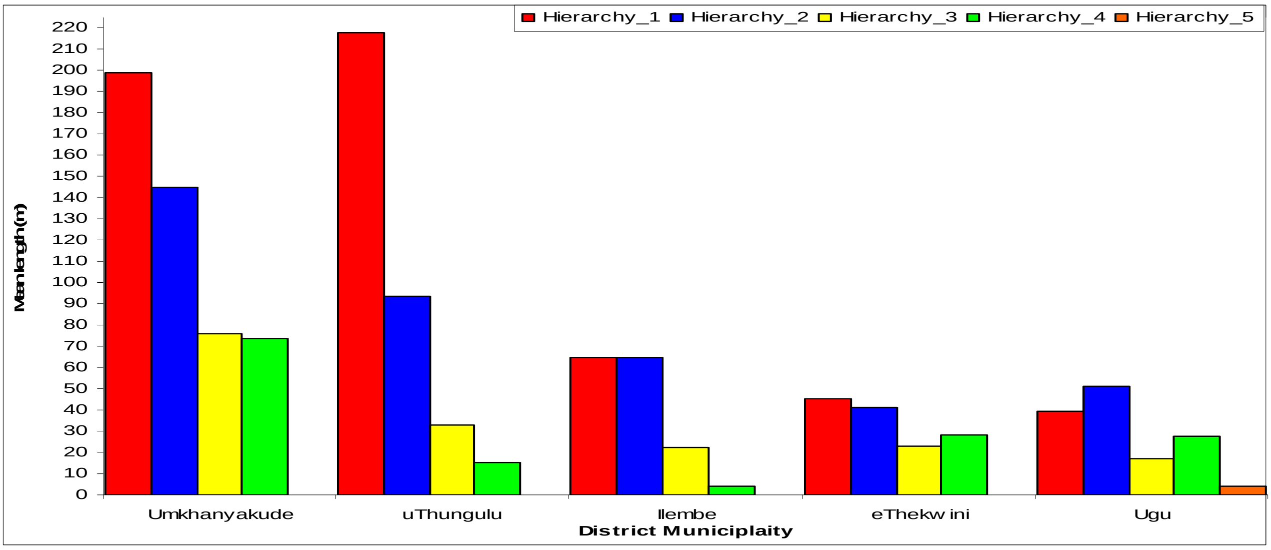

Figure 10. Average length of access routes (m) per hierarchy for each District Municipality.

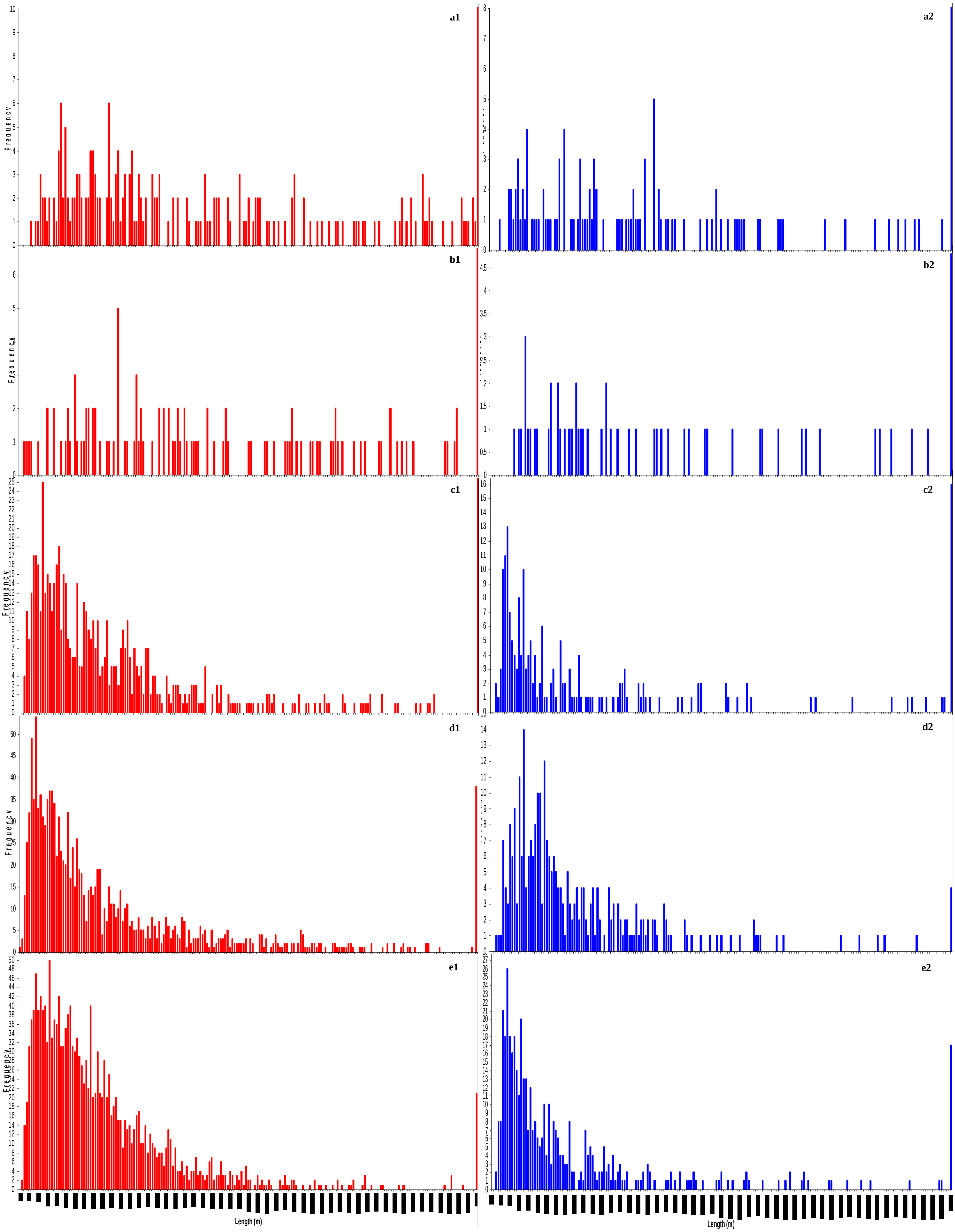

Figure 11a. Length (m) frequency distributions by district (a-e) and Hierarchy (1-2).

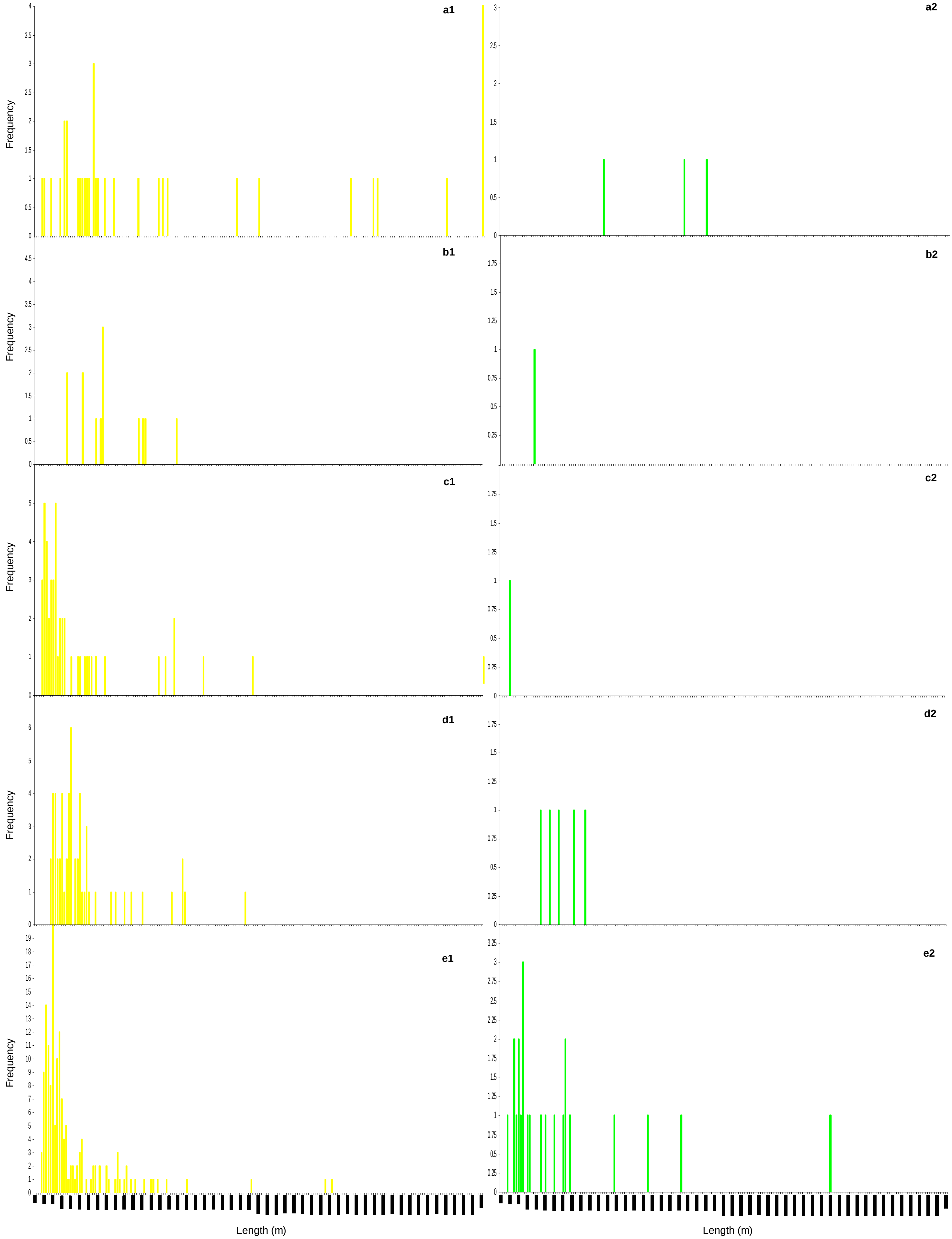

Figure 11b. Length (m) frequency distributions by district (a-e) and Hierarchy (3-4).

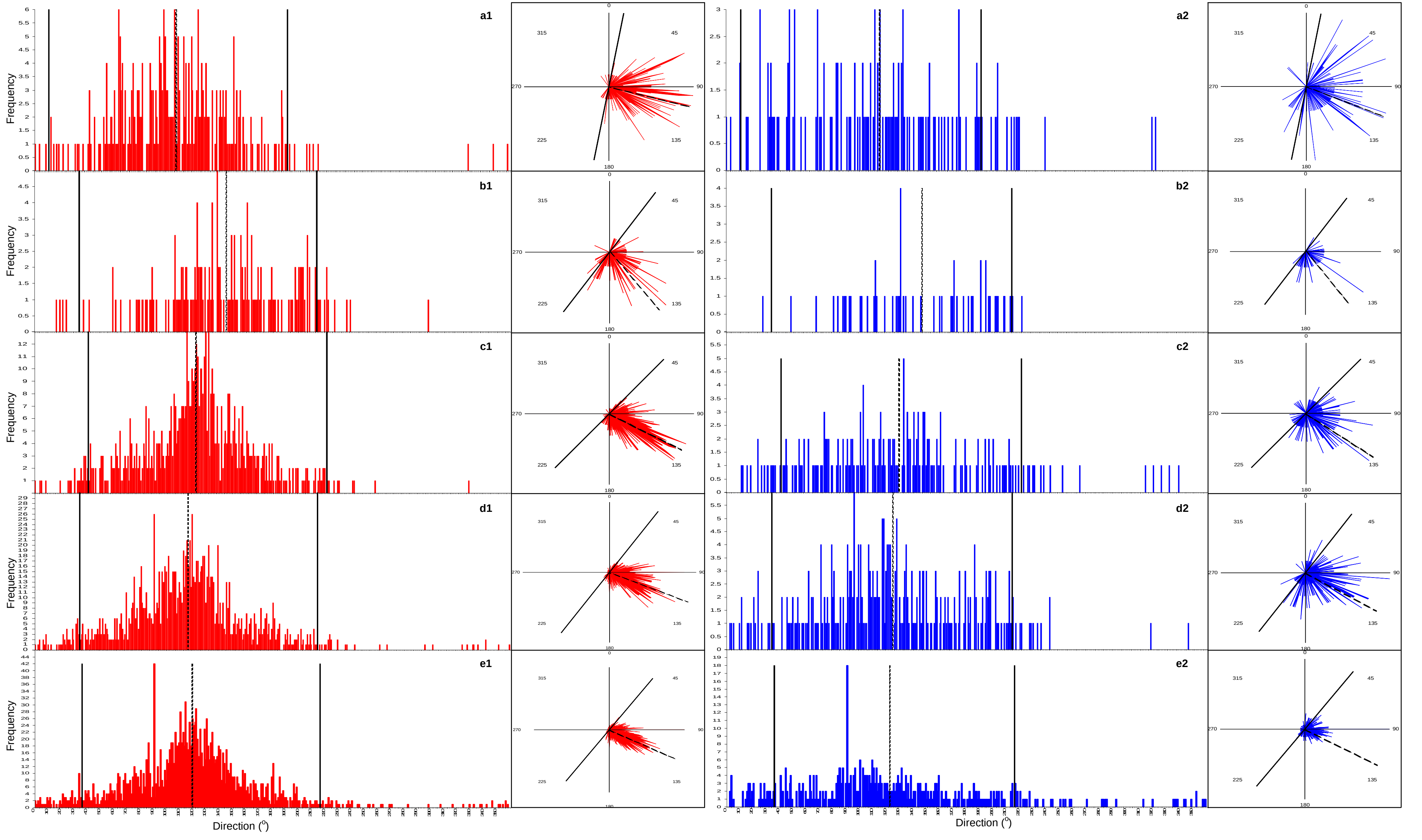

Figure 12a. Direction (degrees) frequency radar graphs and histograms indicating the average direction of the coastline (solid black line) and average direction (dashed black line) for each municipality (a-e) and hierarchy (1-2).

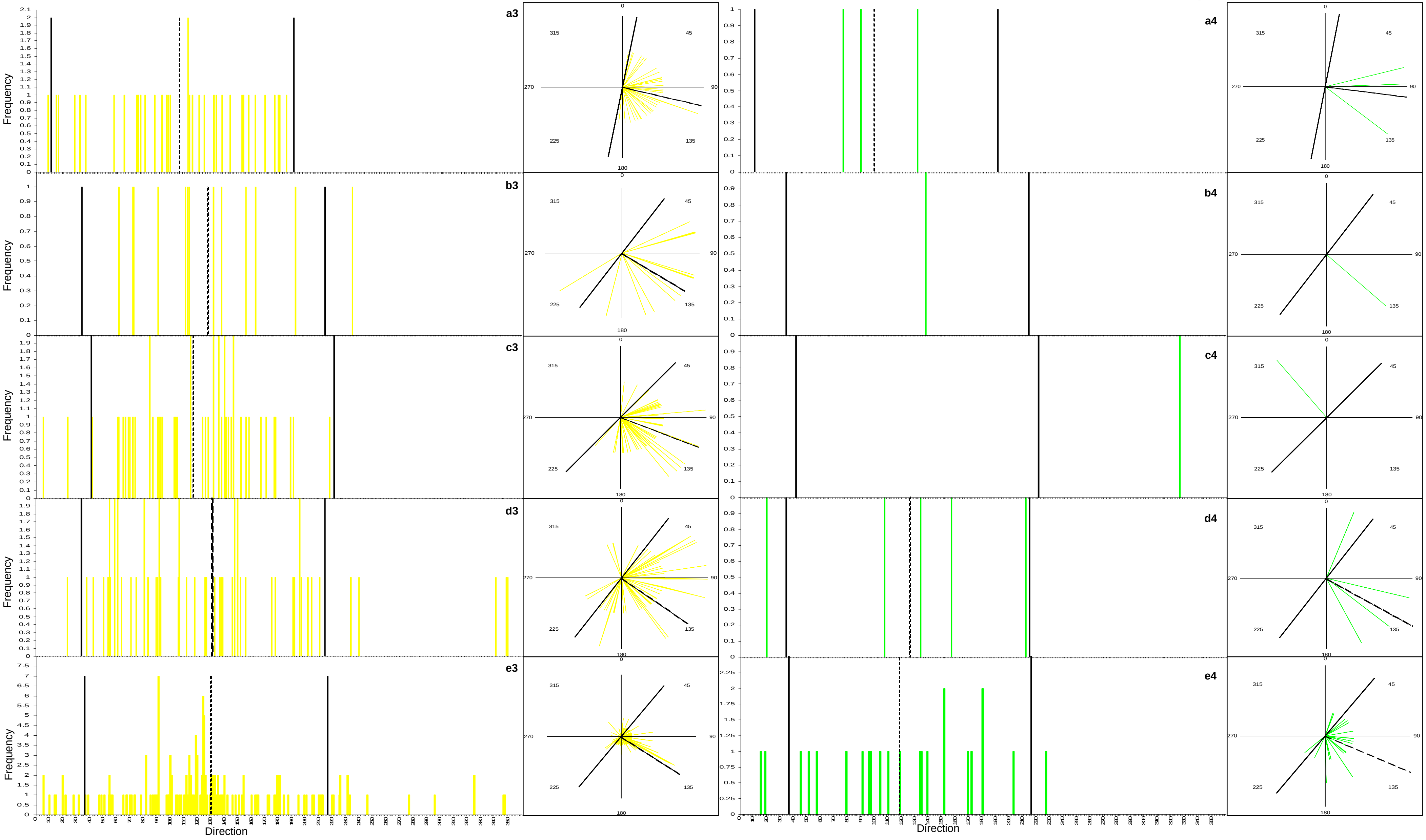

Figure 12b. Direction (degrees) frequency radar graphs and histograms indicating the average direction of the coastline (solid black line) and average direction (dashed black line) for each municipality (a-e) and hierarchy (3-4).

The mean angle of the coastline is similar from Uthungulu southwards with the Umkhanyakude DM having the most northerly angled coastline (Figure 12a and b). The mean direction for the primary and secondary access routes of the two most northern DMs was greater than 90^{o}, i.e. perpendicular, from the angle of the coastline which is the inverse trend shown for the other three DMs where the routes are les than 90^{o} from the angle of the coastline (Figure 12a). The frequency distribution of the Uthungulu primary access routes indicates higher frequencies for directions more than 90^{o} from the coastline than any of the other DMs (Figure 12 a, b1). There was high variability in the direction of secondary access routes for the Umkhanyakude DM and thereby fails to indicate one specifically predominant direction via a single peak in direction frequency (Figure 12a, a2). The peaks in frequency for Uthungulu and Ilembe secondary access route directions were the same and decrease to for eThekwini which was the same direction at which Ugu access routes peaked (Figure 12a b2-e2). The mean direction of tertiary access routes was approximately perpendicular to the coastline for four of the five districts with Ilembe DM's mean occurring at less than 90^{o} with only the Umkhanyakude and Ugu DM indicating peaks in frequency clearly (Figure 12b, a3-e3). Quaternary route directional means only occurred for three of the five districts due to only one quaternary route occurring in those, these mean direction angles decreased from north to south in relation to the average coastline direction (Figure 12b, a4-e4).

Primary route entry points and shoreline exit points generally increased in number from north to south where the number of exit points exceeded the number of entry points for every DM (Figure 13). The average distance between them illustrates the inverse trend from north to south (Figure 13).

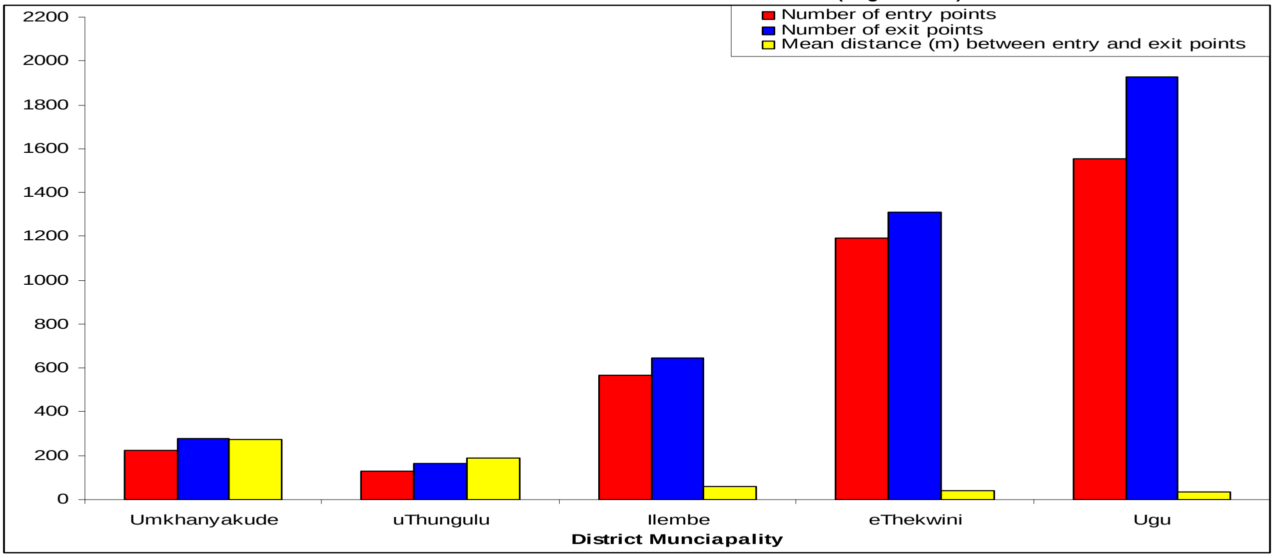

Figure 13. Number of entry and exit points and the mean distance between these for each District Municipality (DM).

The number of simple clusters generally increased from north to south mimicking the total number of access routes per municipality in Figures 3 and 4 (Figure 14).

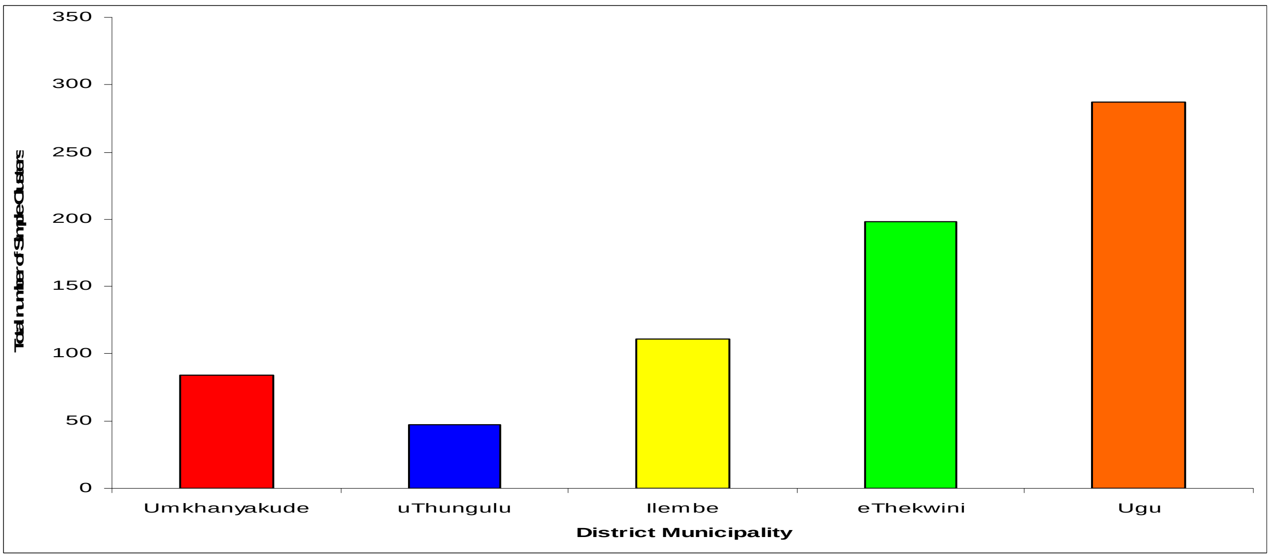

Figure 14. The number of simple clusters in each District Municipality (DM).

The mean simple cluster area decreased from north to south with the highest distance between cluster centroids occurring in the Uthungulu DM (Figure 15). The mean distance between cluster centroids mimicked the results of the mean access route length for each DM in Figures 3 and 5 (figure 15).

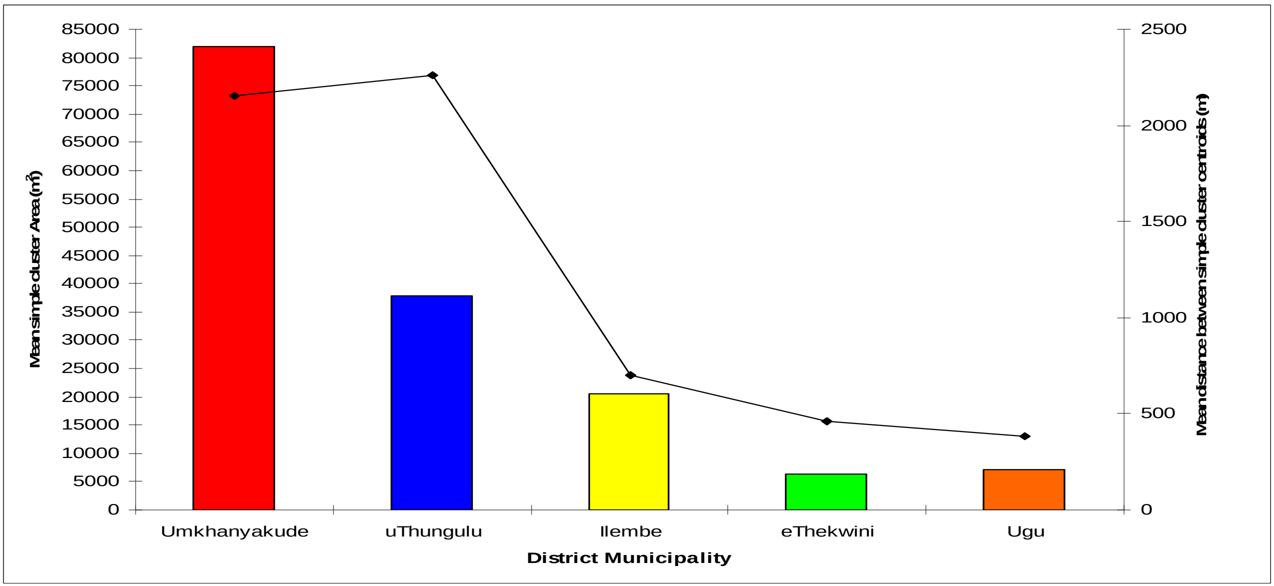

Figure 15.The average simple cluster area (m^2) and the mean distance (m) between simple cluster centroids indicated by the line, for each District Municipality (DM).

The mean number of access routes per simple cluster was highest for Ilembe and lowest for both the Uthungulu and eThekwini DMs (Figure 16). In addition Ilembe had the highest variability in numbers of access routes per simple complex, followed by Ugu DM (Figure 16).

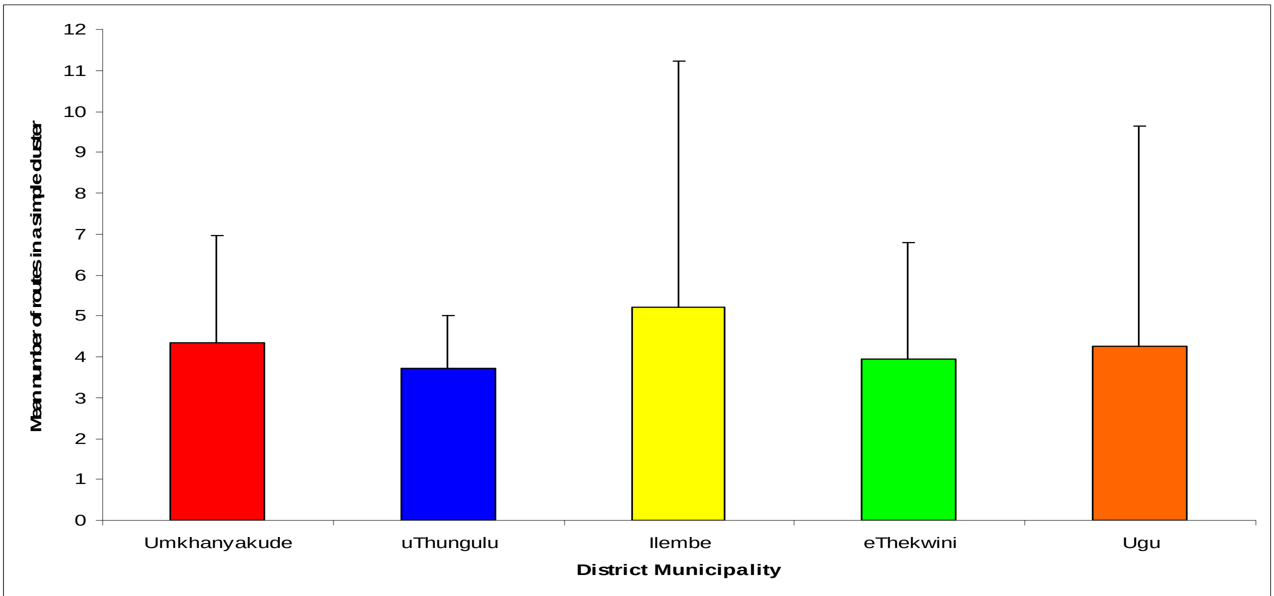

Figure 16. Average number of access routes per simple cluster for in each District Municipality (DM), indicating standard deviation via the error bars.

The average number of simple clusters in a complex cluster was highest for Umkhanyakude, followed by Ilembe and Ugu DMs (Figure 17). The average number of access routes per complex cluster was highest for Ilembe as was the case in Figure 16 for simple clusters (Figure 17). The total number of complex clusters for each DM was higher than the average number of access routes per cluster in all DM except Ilembe DM (Figure 17). The district with the highest number of complex clusters was Ugu where a general decrease in complex clusters follows the numbers of access routes per municipality (Figures 3 and 5) from south to north with the exception of the Umkhanyakude DM (Figure 17).

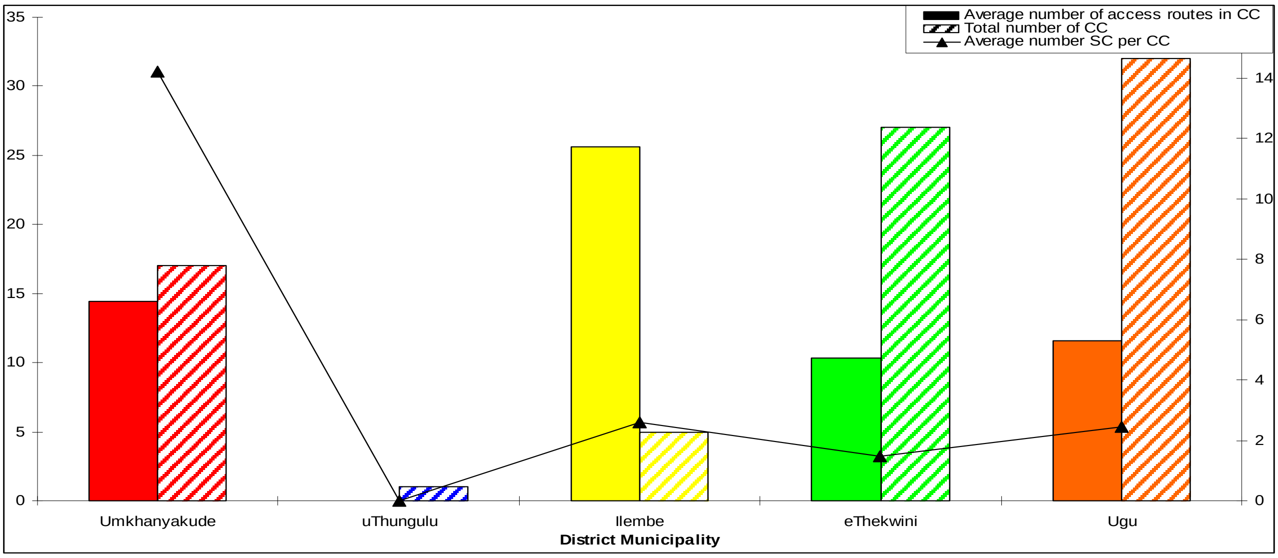

Figure 17. Average number of access routes per complex cluster, total number of complex clusters and the average number of simple clusters per complex cluster for each District Municipality (DM).

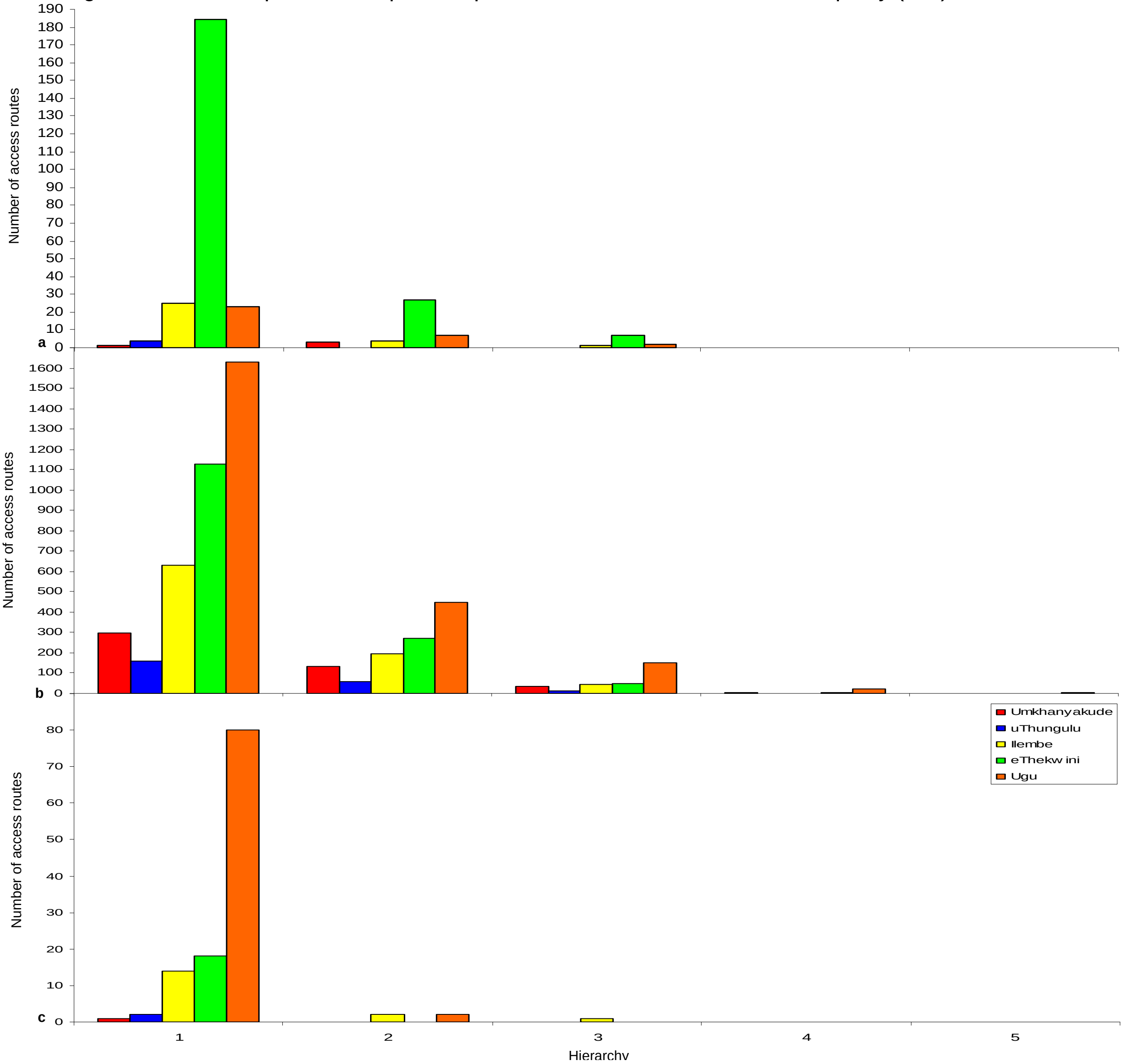

Figure 18. Number of access routes that are a) hard, b) soft and c) contain stretches of both, per hierarchy for each District Municipality (DM).

eThekwini DM had the highest number of access routes with hard surfaces which decreased with an increase in hierarchy (Figure 18a). This decreasing trend occurred for all DMs from hierarchy 1 to 5 (Figure 18). The number of soft access routes increased from north to south for all hierarchies and the Ugu DM was the only DM with quinary access routes (Figure 18 b). Ugu DM had the highest number of access routes that contained stretches of both hard and soft surfaces which decreased with hierarchy (Figure 18c). There was an increase in the number of primary routes of 'mixed' surface type from north to south with Ilembe DM being the only DM which has these routes down to a tertiary level (Figure 18c).

In conclusion

The Umkhanyakude District Municipality (DM) has the longest coastline in the KwaZulu-Natal (KZN) province, the second lowest number of access routes, second highest mean access route length and the second lowest number of access routes per kilometre (km). The average direction of its access routes was closer to east than any other DMs due to the average direction of its coastline being closer to north than the other DMs. This DM had the highest proportion access routes longer than 200m in addition to its access routes varying greatly in both length and direction. Umkhanyakude DM had the longest secondary, tertiary and quaternary access routes in the province. The peaks in length frequency distributions for secondary and quaternary routes were at longer access routes than primary and tertiary routes, respectively. Umkhanyakude had the second lowest number of entry and exit points in the province and the longest average distance between them. The number of exit points was higher than that of the entry points which indicates divergence between them. The number of simple clusters mimicked that of the number of routes in the DM and had the largest mean area for each simple cluster. However, neither the number of access routes in each cluster nor the distance between simple clusters was the highest in the province. Umkhanyakude DM had the highest average number of simple clusters per complex cluster, second lowest number of complex clusters and only the second highest average number of access routes per complex cluster. Lastly, the majority of access routes in this DM have soft surfaces. This DM had sparsely distributed access routes which cover long and large areas with divergence occurring from entry to exit points.

Uthungulu DM had the lowest number of access routes in the province and as a result the highest mean access route length and lowest number of access routes per km of coastline. This municipality and the eThekwini DM had the second shortest coastlines. The average access route direction was the most southerly of all the DM which may be related to the actual direction of its coastline which is masked by its mean direction. The length frequency distribution was similar to that of Umkhanyakude only decreasing slightly in the number of longer length routes. The direction frequency illustrates the above mentioned inability of the mean coastline direction to display the actual directions in relation to the actual direction the coastline follows, which is the most irregular of all the coastal DMs. Uthungulu had the lowest number of access routes for each hierarchy which would be due to the low number of access routes in the DM. Uthungulu had the longest mean primary access route length in the province which was further confirmed by the length frequencies for hierarchy 1 routes. Primary and tertiary routes indicated peaks in length frequency at longer lengths than secondary and quaternary routes. The number of both entry and exit points was the lowest in the province due to them being derived from the number of access routes in the DM. The number of exit points exceeded that of the entry points as was the case with all DMs, however, the mean distance between them was larger in relation to the number of points which was unique to this DM. The number of both simple and complex clusters was the lowest in the province due to the low number of routes in the DM and thereby resulting in the distance between simple clusters being the largest. The mean simple cluster area was second largest to Umkhanyakude and had the number of routes per cluster. Lastly, the majority of the access routes in this DM had surfaces of sand and/or grass. This DM had few, long sparsely distributed access routes diverging between entry and exit areas.

Ilembe DM is the central municipality in terms of location along the coastline. It has the shortest coastline, 917 access routes and approximately 11 access routes per km of coastline. Its length frequency distribution indicated a lower frequency and occurrence of longer routes than the two northern DM and significantly higher frequencies of shorter access routes. The mean direction was approximately perpendicular to the mean coastline angle with a lower occurrence in directions differing from the mean. The mean access route length for primary and secondary access routes was very similar which is seen again in the frequency distributions per hierarchy. The peak length frequency occurred at shorter routes as hierarchy increases. Direction per hierarchy peaked close to the mean for primary, secondary and tertiary access routes, however there was an increase in the number of different directions occurring with an increase in hierarchy. Ilembe's entry and exit points mimicked the number of access routes occurring in this DM as did the number of simple clusters, simple cluster area and the mean distance between simple clusters. This DM contained the highest average number of access routes in each simple and complex cluster. As for Umkhanyakude and Uthungulu, the majority of the access routes were those comprised of sand and/or grass surfaces. This DM could be considered the meridian in terms of its access route results.

eThekwini had the second highest number of access routes, second shortest coastline and the highest number of access routes per km, i.e. highest density, in the province. Its length frequency distribution was similar to that of Ilembe with again a lower frequency and occurrence of longer routes than DMs north of it and a mean direction approximately perpendicular to the mean coastline angle. It is one of two DMs in which quaternary access routes were longer than tertiary ones. What was seen in the length frequency distributions was an increase in the length at which the peak in length frequency occurs with an increase in hierarchy. The direction frequency distributions indicate a large increase in the frequency of access routes following the direction of the coastline from primary to secondary hierarchies. The number of entry and exit points, and the number of simple clusters mimicked the number of access routes in the DM and the distance between them is second shortest in the province. The number complex clusters was second highest in the province with the average number of simple clusters per complex cluster being the second lowest. Unlike the other DMs, eThekwini had the highest number of access routes with hard surfaces for all hierarchies. This municipality had the highest density of access routes and the most striking difference in access route direction between primary and secondary access routes in the province.

Ugu DM had the highest number of access routes, the second longest coastline and therefore the second highest access route density in the province. Its length frequency distribution was the 'narrowest' in terms of lengths. The mean direction was that of approximately perpendicular to the coastline with a peak in the frequency at 90^{o}. Due to its high number of access routes, it had the highest number of routes per hierarchy and was the only DM to have quinary routes. It was the second DM where it's secondary and quaternary access routes were longer than its primary and tertiary routes, respectively. This however, is the opposite trend to what the length frequency distributions display. The direction frequency distribution, as for eThekwini, showed a significant difference in the frequency of access routes running parallel to the coastline between primary and secondary access routes. Due to Ugu having had the highest number of access routes in the province, it has the highest number of entry and exit points, simple clusters and complex clusters and the lowest distance between them. The average area of the simple clusters was second lowest to eThekwini and the average number of access routes in each was second highest to Ilembe. Ugu had the highest number of access routes with soft surfaces and 'mixed' surfaces. This municipality's coastline was characterised by many short sandy and/or grassy access routes fairly densely distributed along its shoreline.

It is recommended that analyses on complex cluster area, distance between complex cluster centroids, direction of access points in relation to the coastline direction and proportions of access routes rather than total number of access routes be completed to complete this situational analysis.

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